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oscilloscope

INSTRUCTION MANUAL

VACUUM TUBE PRODUCTS DIVISION

HUGHES

HUGHES AIRCRAFT COMPANY

E.E.D. CALIBRATION LAB.

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model 105A

**INSTRUCTION
MANUAL**

Creating a new world with ELECTRONICS

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CIRCUIT CHANGE NOTICE

1. Page 69.

L211 has been changed from 10-18 to 16-28 microhenry.

2. Page 75.

R619 and R620 have been changed from 2.2 Meg. to 1.0 Meg.

3. Figure 16. Sweep Trigger-Horizontal Amplifier Assembly A-106603.

Change designation of R513 to R530.

4. Vertical Amplifier. Schematic Dwg. A-106902.

R247 has been changed from 5.6K, 1 Watt to 5.6K, 2 Watt.

R236 and R237 have been changed from 6.2K, 1/2 Watt to 12K, 2 Watt.

5. Low Voltage Power Supply. Schematic Dwg. A-106906.

R619 has been changed from 2.2 Meg. to 1.0 Meg.

6. High Voltage Power Supply. Schematic Dwg. A-106907.

Output pin jacks indicated on the High Voltage Power Supply schematic should be corrected to read as follows:

P714 should read P713

P715 should read P714

P712 should read P710

P713 should read P712

TABLE OF CONTENTS

	<u>Page</u>
SECTION I. SPECIFICATIONS	1
SECTION II. GENERAL DESCRIPTION	4
2-1. MEMO-SCOPE Oscilloscope, Model 105A	4
2-2. MEMOTRON Storage Tube	5
2-3. Front Panel Control & Connectors	6
2-4. Accessories	9
SECTION III. OPERATING INSTRUCTIONS	11
3-1. Introduction	11
3-2. Operation	11
SECTION IV. CIRCUIT DESCRIPTION	21
4-1. Block Diagram	21
4-2. Vertical Deflection System	21
4-3. Horizontal Deflection System	23
4-4. Storage Circuits	30
4-5. Calibrator	31
4-6. Power Supplies	32
SECTION V. MAINTENANCE & SERVICE	37
5-1. Replacement of Components	37
5-2. Soldering	37
5-3. Disassembly	37
5-4. Trouble Shooting	39
5-5. Voltage Measurements	47
SECTION VI. CALIBRATION & ADJUSTMENT	51
6-1. Recalibration Sequence	51
6-2. Calibration Equipment	52
6-3. Preconditions	52
6-4. Low Voltage Power Supply	52
6-5. Horizontal & Vertical Deflection Plate Levels	53
6-6. High Voltage Power Supply	53
6-7. Sweep Circuit Adjustments	54

	<u>Page</u>
6-8. Calibrator Adjustment	56
6-9. Horizontal Deflection System	56
6-10. Multiplier Calibration	57
6-11. Magnifier Calibration	58
6-12. Vertical Amplifier Calibration	60
6-13. Storage Circuit Calibration	62

SECTION VII. PARTS LIST

7-1. Ordering Procedure	65
7-2. Storage Controls	65
7-3. Vertical Amplifier	67
7-4. Horizontal Amplifier	70
7-5. Trigger Amplifier	71
7-6. Sweep Generator	72
7-7. Low Voltage Power Supply	75
7-8. High Voltage Power Supply	78
7-9. Calibrator	80
7-10. Z-Axis Circuit	81

SECTION VIII. SCHEMATIC DIAGRAMS

Dwg. No. A-106900	Block Diagram
Dwg. No. A-106901	Memotron Storage Controls
Dwg. No. A-106902	Vertical Amplifier
Dwg. No. A-106903	Horizontal Amplifier
Dwg. No. A-106904	Trigger Amplifier
Dwg. No. A-106905	Sweep Generator
Dwg. No. A-106906	Low Voltage Power Supply
Dwg. No. A-106907	High Voltage Power Supply
Dwg. No. A-106908	Calibrator
Dwg. No. A-106909	Z-Axis Circuit
Dwg. No. A-106913	Dual Trace Blanking Circuit

LIST OF ILLUSTRATIONS

Figure 1.	MEMO-SCOPE Oscilloscope, Model 105A
Figure 2a.	MEMOTRON Storage Tube
Figure 2b.	Storage Elements
Figure 3.	Front Panel Controls
Figure 4.	Vertical Deflection System
Figure 5.	Horizontal Deflection System
Figure 6.	Sweep Circuitry (normal mode)
Figure 7.	Sweep Circuitry (single sweep mode)
Figure 8.	Left Side (cover removed)
Figure 9.	Right Side (cover removed)
Figure 10.	Storage Controls Printed Circuit Board
Figure 11a.	Vertical Amplifier Printed Circuit Board (front view)
Figure 11b.	Vertical Amplifier Printed Circuit Board (rear view)
Figure 12.	Sweep Trigger-Horizontal Amplifier Printed Circuit Board
Figure 13.	Low Voltage Regulator Printed Circuit Board
Figure 14.	Low Voltage Rectifier Printed Circuit Board
Figure 15.	High Voltage Power Supply Printed Circuit Board
Figure 16.	Dual Trace Blanking Circuit Board
Figure 17.	Rear View of MEMOTRON tube.

SECTION 1 SPECIFICATIONS

1-1. MEMOTRON Storage Tube, Direct Display CRT, Model H-1051.

Writing Speed in Storage Mode: 1,000,000 inches/sec.
Deflection Sensitivity: 8 Volts per division at plates.
Erasure: Less than 150 millisec. Accomplished by front panel pushbutton or by external source.
Contrast Ratio: 3:1 minimum.
Accelerating Potentials: (measured with respect to ground).
Writing gun: -1.5 kv
Viewing Screen: +4 kv.
Diameter: 5" nominal, 4" minimum useable display surface.
Phosphor: Pl.

1-2. Vertical Deflection System. Overall sensitivity and bandwidth dependent upon preamplifier used. The following specifications are for use with the 05-1 WIDEBAND, General Purpose Pre-amplifier.

Sensitivity: 50mv/div to 20 v/div.
Bandwidth: DC to 10 Megacycles.
Rise Time: 35 nanoseconds.
Input Impedance: 1 megohm, shunted by 50 uuf.
Signal Delay: Built-in 0.25 usec delay line.

1-3. Sweep Generator.

Range: 0.1 usec to 1 sec/div in 8 major steps.
Linearity: $\pm 1\%$
Accuracy: $\pm 3\%$
Fixed Multiplier: 9 steps multiplying 1X through 9X
Variable Multiplier: Continuous control between fixed steps for speeds as low as 10 sec/div.
Sweep Magnification: 5X for speeds as fast as 20 nanosec/div.
Operating Modes: Triggered, free-running, or "one shot" sweep.
Trigger Modes: AC/DC on Internal \perp , External \perp , or Line \perp .
Trigger Sensitivity: Nominally 1/2 of 1 division of vertical deflection.

1-4. Horizontal Amplifier.

Sensitivity: (with 5X magnifier) nominally 0.35 volts per division, continuously variable.
Bandwidth: DC to 350 kc at full gain.
Input Impedance: Nominally 0.1 megohm, shunted by 50 uuf.

1-5. Calibrator.

Output: Square wave, nominal frequency 1KC.
Range: Selection of 18 ranges from 0.2 millivolts to 100 volts.
Accuracy: $\pm 3\%$.

1-6. Power Requirements.

117/234 volts $\pm 10\%$, 50/60 cps, 500 watts.

1-7. Power Supplies.

DC voltages electronically regulated: +500v, +360v, +270v,
+170v, +100v, -150v,
-48v.

Unregulated: ± 430 v.

High voltages: Regulated RF supply furnishes viewing screen potential of approx. 4 kv and writing gun potential of approx. -1.5 kv.

1-8. Front Panel Jacks.

External Sync: Nominally 1 volt peak-to-peak input required for triggering. If trigger source is DC referenced to other than ground, best results will be achieved by using AC MODE.

External Sweep: Sensitivity with 5X magnifier is 0.35 volts/div. If sweep source is referenced appreciably higher or lower than ground, AC coupling is recommended.

Calibrator: Square wave output, nominal frequency 1 kc. 0.2 millivolts to 100 volts peak-to-peak.

External Erase:	Terminal to be grounded by external switch when external erasure is desired. Terminal has a positive potential dependent on THRESHOLD setting; may be as high as +375v through a 68K series resistor.
External Blanking:	Terminal provided for Z-Axis modulation. Requires 0 to +10 volt signal for blanking of writing beam.
+ Gate:	Positive-going rectangular waveform during active portion of sweep. Referenced to ground, nominally 60 volts amplitude.
Sweep Out:	Positive-going sawtooth referenced to ground, nominally 150v amplitude.
Ground:	Convenient terminal for grounding.

1-9. Mechanical Specifications.

<u>Overall Dimensions</u>	<u>Portable</u>	<u>Rack Mounted</u>
Height	16 7/8"	17 1/2"
Width	13"	19"
Depth	23 1/4"	23 1/4"
Net Weight	58 lbs.	63 lbs.
Shipping Weight	75 lbs.	80 lbs.

Finish: Anodized aluminum front panel, Vinyl-clad covers.
Cooling System: 5" fan, washable filter.

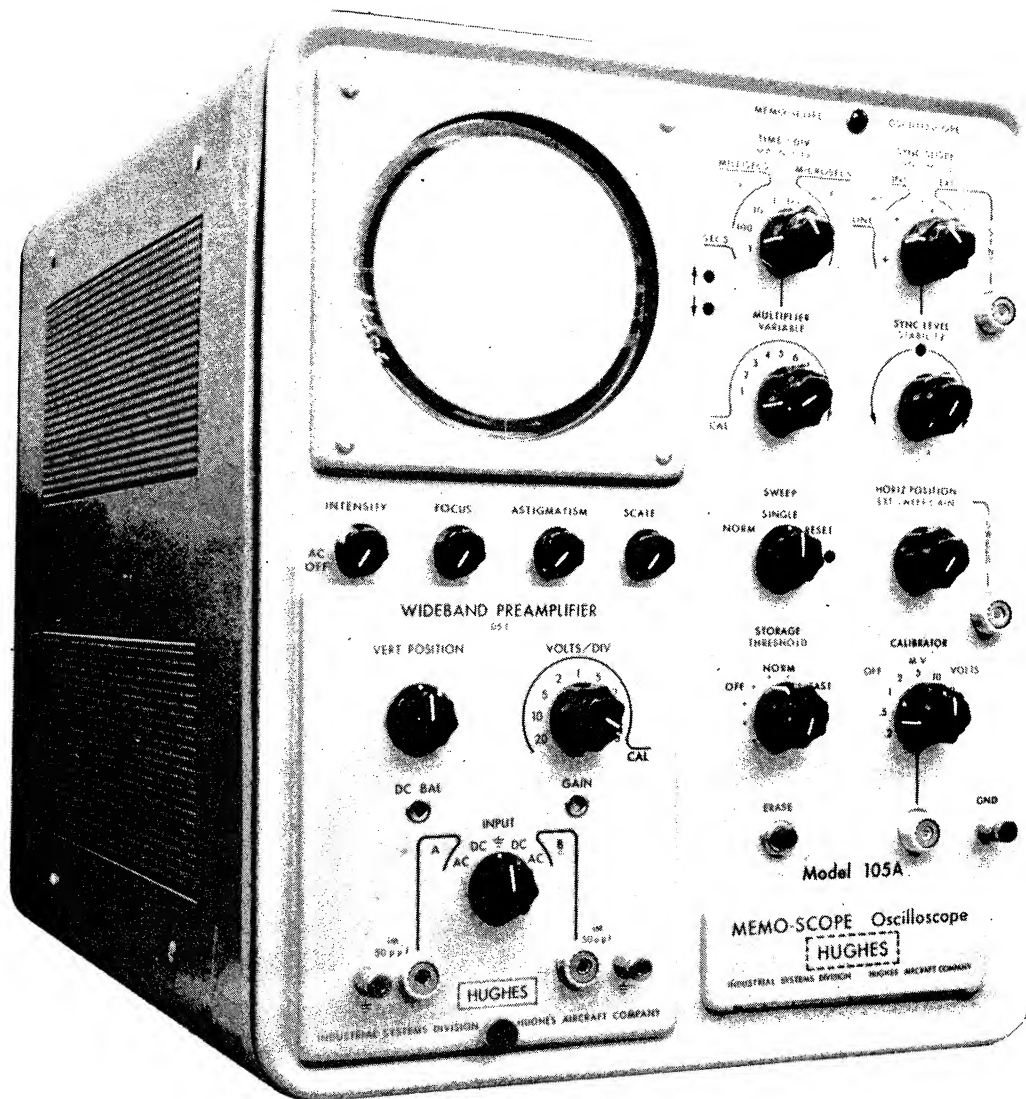


FIGURE 1 MEMO-SCOPE OSCILLOSCOPE, MODEL 105A

SECTION II GENERAL DESCRIPTION

2-1. The Hughes MEMO-SCOPE Oscilloscope, Model 105A, is an advanced laboratory-type instrument designed to test any type of equipment where performance can be translated into an electrical signal. The instrument is built around the MEMOTRON storage tube, which permits use of the oscilloscope as a storage-type instrument of long persistence, or as a conventional high-speed oscilloscope.

In the storage mode, the MEMO-SCOPE Oscilloscope affords a visual presentation of all pertinent phenomena related to the equipment under test, including transient traces which are difficult or impossible to measure by other means. Traces remain visible at uniform brightness indefinitely, without fading or blooming, until intentionally erased. Successive writings may be superimposed or shifted in position for convenient comparison. Resolution up to 20 adjacent written lines per inch permits excellent interpretation of complex patterns. Reference lines can easily be stored on the face of the MEMOTRON tube as an aid in making accurate measurements. Traces that exceed the maximum writing speed of 1,000,000 inches per second in the storage mode can be visibly displayed by repeated retracing at repetition rates sufficiently high to permit cumulative storage. These unusual features simplify test analyses and facilitate initial design of equipment by revealing hidden factors which affect performance.

Wide bandwidth permits detailed examination of complex waveforms. A delay network insures presentation of all the incoming signal without loss of leading edges. Precision circuitry throughout the instrument affords a high level of accuracy in making measurements.

Power supplies are connected to critical components in a manner providing adequate protection in the event of component failure. The storage circuitry has been designed to minimize the possibility of damage to the storage surface of the MEMOTRON tube in event of accidental operator error.

Major circuit boards are mounted on hinged frames, all components are easily reached for servicing. Filtered forced-air cooling prevents overheating of the oscilloscope. The chassis is all aluminum, with removable vinyl-clad covers. A series of plug-in preamplifiers are available as accessories, as well as the Hughes Multitracer, which permits comparison of a selected number of consecutive sweeps simultaneously.

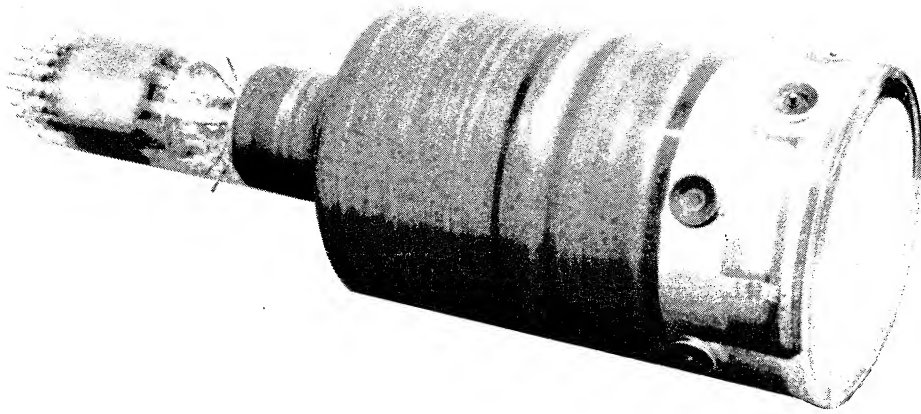


FIGURE 2a MEMOTRON STORAGE TUBE

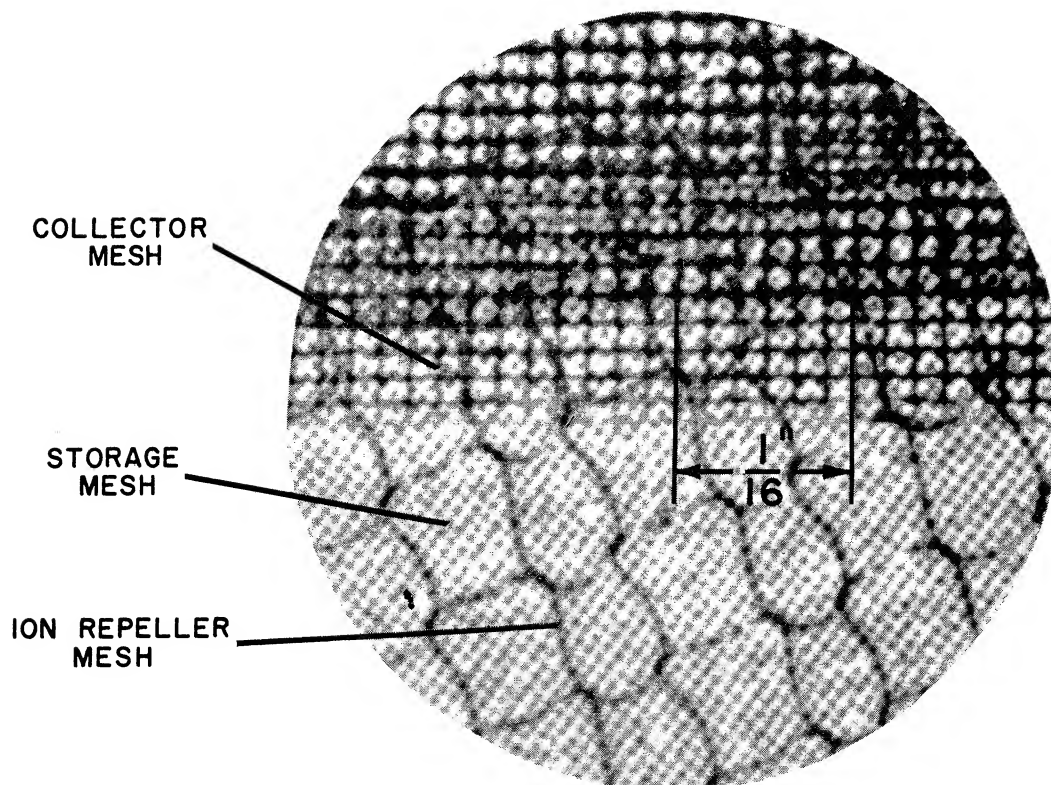


FIGURE 2b STORAGE ELEMENTS

2-2. MEMOTRON Storage Tube. The MEMOTRON Storage Tube is a special cathode-ray tube designed for a dual function. When used as a storage or "memory" device, impressed waveforms may be stored indefinitely for prolonged observation. The tube may also be operated with standard oscilloscope circuitry in the conventional manner.

A simplified cross section of the MEMOTRON tube is shown in Figure 2. The principal elements of the tube are a conventional writing gun, a pair of flood guns, a storage assembly and a phosphor viewing screen. The storage assembly consists of a storage mesh, one side of which is coated with a deposit of dielectric material, and a secondary electron collector mesh. An ion repeller mesh is included to prevent stray ions from discharging portions of the storage mesh. Since operation of the tube with conventional oscilloscope circuitry is the same as with any standard instrument, only the storage functions are described in the following paragraphs.

In the unwritten state, the dielectric material on the storage mesh is at flood gun cathode or "zero" potential. When the high velocity electron beam from the writing gun strikes the dielectric material, secondary emission results having a ratio greater than unity, i.e., more secondary electrons leave the dielectric surface than primary electrons which strike it. The areas struck by the writing beam are thus charged in a positive direction. The collector mesh, operated at a higher positive potential than the storage mesh, attracts and collects the secondary electrons.

The flood guns are collimated to provide an even distribution of low-velocity electrons over the entire storage surface. Flood gun electrons striking the written areas cause a further secondary emission carrying the potential of these areas to collector mesh potential. A portion of the flood gun electrons pass through the now positively charged written areas, and accelerated by the high positive potential of the viewing screen, strike the phosphor with sufficient energy to cause fluorescence. Thus, a continuously visible image of the pattern written on the storage mesh is produced on the viewing screen.

Any tendency of the written areas of the storage mesh to fall below collector mesh potential is overcome by the flood gun electrons, permitting indefinite storage of the impressed waveforms.

In the unwritten areas, which are near "zero" potential, flood electrons strike the dielectric surface with near zero velocity and cause no secondary emission. The surface potential of the unwritten areas is

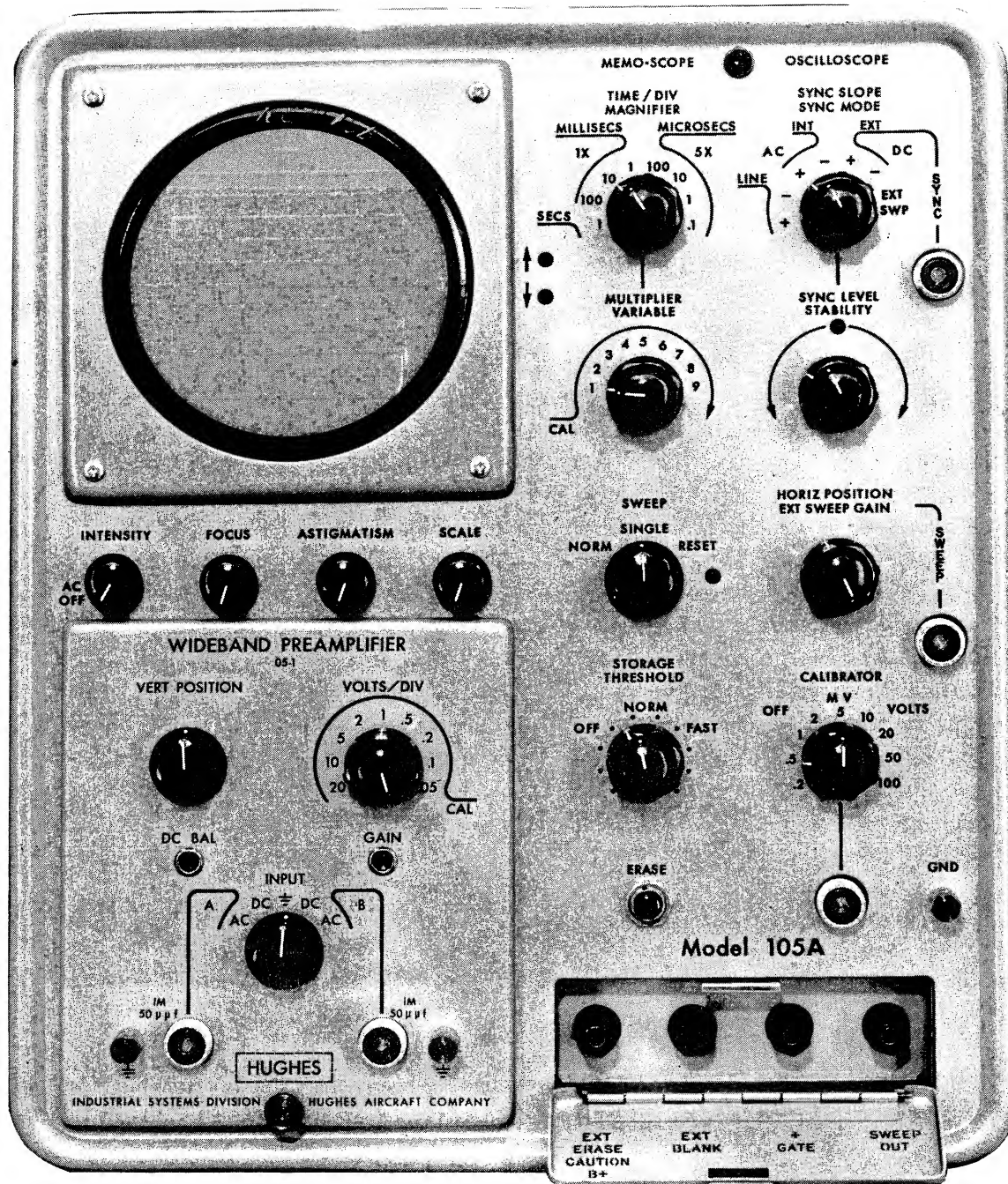


FIGURE 3 FRONT PANEL CONTROLS

prevented from rising above "zero" by the negative charging action of the low-energy flood electrons.

Erasure of the stored pattern is accomplished by momentarily decreasing the positive potential of the collector mesh below a critical point. Regeneration of the written areas on the storage mesh is eliminated, and their potential reduced to zero volts.

When the instrument is operated as a conventional oscilloscope, the flood guns are cut off. The collector mesh is set at ground or "zero" potential, permitting the writing beam to pass to the viewing screen.

2-3. Function of Controls and Connectors

INTENSITY	Potentiometer R712 with ON-OFF switch controls intensity of writing beam.
FOCUS	Potentiometer R718 controls focus of writing beam.
ASTIGMATISM	Potentiometer R116 optimizes shape of writing beam spot.
SCALE	Potentiometer R608 controls illumination of scale markings on graticule.
TIME/DIV	8 position switch S501 selects sweep speeds from 1 second per graticule division to .1 microsecond per graticule division by factors of 10.
MAGNIFIER (red knob)	2 position switch S301 provides X5 magnification of horizontal time base (X-Axis).
SYNC SLOPE	7 position switch S401 selects source and polarity of sweep triggering signal. Selects External Sweep in 7th position.
SYNC MODE (red knob)	2 position switch S402 selects a-c or d-c triggering mode for triggering signal selected by SYNC SLOPE switch.
EXT SYNC	Coaxial connector J401 for external triggering of oscilloscope.

MULTIPLIER	9 position switch S502 selects multiplier of sweep duration as provided by TIME/DIV switch.
VARIABLE (red knob)	Potentiometer R551 with Switch S503 for continuous control of sweep speeds between calibrated positions. Switch cuts off variable mode and cuts in calibrated positions.
SYNC LEVEL	Potentiometer R411 determines amplitude of triggering waveform at which sweep will begin.
STABILITY (red knob)	Potentiometer R513 determines triggering region to provide for free-running or synchronous operation of sweep.
SWEEP	3 position switch S403 selects mode of operation of sweep. In the NORM position, oscilloscope operates in recurrent mode. In the SINGLE position, oscilloscope operates in single sweep mode. The RESET position is spring-loaded, and provides for re-arming of the single sweep circuitry.
HORIZ POSITION	Potentiometer R305 controls position of trace along horizontal axis.
EXT SWEEP GAIN (red knob)	Potentiometer R307 controls length of horizontal sweep produced by external signals.
EXT SWEEP	Coaxial connector J301 for introduction of external horizontal sweep signal.
STORAGE	3 position switch S101 provides for control of storage mode and speed enhancement. In the OFF position, the oscilloscope operates in the non-storage mode. In the NORM position, the instrument operates in the normal storage mode, and can be triggered successively without erasure. In the FAST position the storage mode provides for capture of high speed, single sweep phenomena.
THRESHOLD (red knob)	Potentiometer R111 provides for adjustment of the level where the MEMOTRON tube begins to store.

ERASE	Push-button switch S102 for erasure of traces stored on viewing screen.
CALIBRATOR (black knob)	9 position switch S802 selects calibrated amplitude of square wave available at CAL OUT jack J801.
CALIBRATOR	3 position switch S801 turns calibrator off or provides output in either millivolts or volts as indicated by CALIBRATOR black knob setting.
GND	Binding post provides grounding point for external equipment.

The following connectors are located in the covered, recessed compartment located at the bottom of the front panel.

EXT ERASE	Binding post J101 providing input for erasure by external signals.
EXT BLANK	Binding post J903 providing input for external signals used to blank the writing beam.
+ GATE	Binding post J902 providing outlet for positive-going pulse of approximately 40 volts, synchronized with sweep. Cathode follower output, d-c coupled.
SWEEP OUT	Binding Post J501 providing outlet for positive-going sawtooth sweep waveform of approximately 150 volts. Cathode follower output, d-c coupled.

2-3-1. Indicator Lamps.

VERTICAL POSITIONING INDICATOR LIGHTS	Two neon lamps I201, I202 are located at right of viewing screen. The upper lamp is lighted when the writing beam is off screen at top of the tube face. The lower lamp is lighted when the beam is off screen at the bottom.
HORIZONTAL SWEEP INDICATOR LIGHT	Located above STABILITY control. Neon indicator lamp I501 is lighted when sweep is operating and the writing beam is moving across the screen.

RESET LIGHT

Neon indicator lamp 1401 located below sweep reset position is lighted when single sweep circuitry is "armed".

2-4. Accessories. The following accessories are available for use with the MEMO-SCOPE Oscilloscope, Model 105A. Separate manuals are available for each type of preamplifier, and for the Hughes Multitracer.

2-4-1. Preamplifiers.

Model 05-1 WIDEBAND Preamplifier is a wide-band, general purpose preamplifier designed for a wide variety of applications. Two inputs, selected by a front panel switch permits either a-c or d-c coupling.

Model 05-2 DUAL TRACE Preamplifier is specially designed for simultaneous presentation of two related phenomena. The unit provides two separate inputs and separate amplifier channels for each input. Input signals may be displayed separately, alternately, or switched at a high rate (chopped mode). Separate controls are provided for each channel.

MODEL 05-3 HIGH GAIN DIFFERENTIAL Preamplifier provides high sensitivity for signals of low amplitude. The unit is a differential amplifier with a high common-mode rejection ratio. Low level signals which are impressed on signals of a much higher level are amplified for display on the oscilloscope screen.

2-4-2. Hughes Multitracer. The Multitracer enables presentation and storage of consecutive sweeps for simultaneous display. A storage counter circuit adds a d-c positioning voltage or vertical step to the incoming signal during the retrace period. This provides automatic stepping of each consecutive sweep, each sweep being presented as a separate trace, stepped down the face of the MEMOTRON tube. In effect, the Multitracer increases the diameter of the storage tube. Up to 10 traces may be stored for comparison in this manner.

2-4-3. Scope Cart. Part No. A-106400. The Hughes Scope Cart accommodates all models of MEMO-SCOPE Oscilloscopes. The cart is of sturdy tubular aluminum construction with large diameter, rubber tired swivel casters. A convenient storage cabinet accommodates accessory preamplifiers. Other features include a 6 foot retractable power cord, ample drawer space and a pull-out writing board.

2-4-4. Probes. Part No. A-106420. A convenient, pen-sized test probe with miniature alligator jaws is available as an accessory. The probe has a capacitance of 10 uuf, an impedance of 10 megohms and provides a 10:1 voltage division. Capacitance is easily compensated by rotating one portion of the probe barrel.

2-4-5. Camera Mount. Part No. A-106411. An all aluminum mount adaptable to any conventional oscilloscope camera. A snap lock holds camera securely against the viewing screen. The mount is hinged, permits the camera to swing out of the way when not in use.

2-4-6. Capacitance Standardizer. Part No. A-106406. The Hughes Capacitance Standardizer is used to adjust the input capacitance of the various preamplifiers used with the MEMO-SCOPE Oscilloscope, Model 105A. When the input capacitance of the attenuators has been set to 50 uuf and 1 megohm with the standardizer, preamplifiers can be interchanged with a minimum of mismatching. A convenient switch mounted on the body of the standardizer permits selection of a low impedance direct connection or a high impedance (1 megohm shunted by 50 uuf) connection to signal source.

2-4-7. Preamplifier Extension Plug. Part No. A-106430. The extension plug fits between the preamplifier and the oscilloscope receptacle to permit access to all adjustment points of the preamplifier during servicing.

SECTION III OPERATING INSTRUCTIONS

3-1. Introduction. The MEMO-SCOPE Oscilloscope, Model 105A is a precision-built laboratory instrument. It has been carefully designed to provide performance of the highest level over a long period of time. To insure a long operating life and to preclude unnecessary difficulties, the operating instructions given in this manual should be followed in sequence at least once. Do not hesitate to call one of the company representatives to review the operation of the instrument with your personnel.

3-2. Operation. This manual has been prepared for use of the oscilloscope in conjunction with the Model 05-1 Wideband, general purpose preamplifier. Operating instructions for use of the instrument with other preamplifiers will be found in separate manuals.

The units are normally wired at the factory for 117 volt, a-c operation. Special order units are furnished for 234 volt operation. Before applying power, check the label at the rear of the instrument, to insure that the power transformer has been wired for your source of power. To change this wiring, refer to Drawing A-105906.

New units are shipped with the fuse holder attached to the carrying handle. Remove the fuse holder and insert it in the fuse post holder at the rear of the oscilloscope. A 5 ampere 3 AG-MDL fuse is required for 117 volt operation, and a 3 ampere 3 AG-MDL fuse for 234 volt operation.

3-2-1. Turn-On-Procedure. Insure that the oscilloscope is positioned without blocking the air inlet to cooling fan. Insert Model 05-1 Preamplifier. Set front panel controls as follows:

- Power Switch OFF. (located on INTENSITY Control).
- SCALE fully counter-clockwise.
- ASTIGMATISM fully counter-clockwise.
- FOCUS fully counter-clockwise.
- SYNC MODE in AC position.
- SYNC SLOPE in INT+ position.
- VERT POSITION to mechanical center.
- HORIZ POSITION to mechanical center.
- STORAGE OFF.

THRESHOLD fully counter-clockwise.
TIME/DIV to 100 usec.
MULTIPLIER to 2.
SWEEP to NORM.
SYNC LEVEL fully counter-clockwise.
STABILITY fully clockwise.
MAGNIFIER IX.
VARIABLE to CAL.

3-2-1-1. Set the preamplifier VOLTS/DIV control to 1 volt per division, the INPUT selector switch to A-AC and the Variable VOLTS/DIV (red knob) fully counter-clockwise.

3-2-1-2. Insert power cord at rear of unit. Turn the combination Power Switch-Intensity Control clockwise to actuate the power switch. Continue to turn the INTENSITY control clockwise for approximately 120 degrees. Insure that FOCUS control is fully counter-clockwise.

3-2-1-3. Allow 1 minute for warm-up. The automatic time delay relay insures filament warm-up before power is applied to other circuitry.

3-2-1-4. Center the VERT POSITION control and observe trace on viewing screen. If trace is not observable, adjust the preamplifier DC BAL (screwdriver adjust) control until a trace is visible in the center of the screen.

3-2-1-5. Turn the VERT POSITION control clockwise until the upper positioning indicator light turns on. Turn control counter-clockwise until the lower light turns on. This will familiarize the operator with the vertical positioning of the writing beam.

3-2-1-6. Adjust the VERT POSITION and HORIZ POSITION controls to center the trace.

3-2-1-7. Adjust FOCUS and ASTIGMATISM controls for the sharpest line.

3-2-1-8. Adjust SCALE control for desired illumination of graticule.

3-2-1-9. Turn the VARIABLE VOLTS/DIV control (red knob) fully counter-clockwise. Center the trace with the VERT POSITION control.

Turn the Variable VOLTS/DIV control to the CAL position (fully clockwise). If the trace remains centered within 1/2 graticule division, the preamplifier is d-c balanced and ready for operation. If the trace does not remain centered within 1/2 division, refer to the balancing procedure outlined in the appropriate preamplifier manual.

3-2-2. Normal Sweep Operation

3-2-2-1. Follow Turn-On Procedure described in 3-2-1 through 3-2-1-9. Insure that Variable VOLTS/DIV control is set to CAL position.

3-2-2-2. Set CALIBRATOR red knob to VOLTS, and CALIBRATOR black knob to 5.

3-2-2-3. Connect a lead from CALIBRATOR output jack to preamplifier INPUT A.

3-2-2-4. Observe two free running traces on the face of the screen. Using the vertical and horizontal positioning controls, position the traces for convenient viewing.

3-2-2-5. Set SYNC LEVEL at mechanical center. Turn STABILITY control counter-clockwise until a series of square waves appears on the screen. Note that with SYNC SLOPE control set at INT+, the display starts on the positive-going portion of the square wave.

3-2-2-6. Set SYNC SLOPE control to INT_. Note that display starts on the negative-going portion of the square wave.

3-2-2-7. Note that the oscilloscope can be synchronized at line frequency by switching the SYNC SLOPE switch to LINE+ or -. This is useful in observing ripple content of incoming signals. By setting the SYNC SLOPE switch to EXT+ or -, the display can be synchronized from an external source fed into the SYNC input jack. The SYNC MODE switch can be used to a-c or d-c couple the selected triggering source. The EXT SWEEP position on the SYNC SLOPE switch can be used to bypass the internal trigger and sweep generator and provide a d-c coupled connection from the horizontal amplifier to the external sweep input jack. Operation is further explained under 3-2-10, X-Y Plotting.

3-2-2-8. Set SYNC SLOPE control at INT+ and SYNC MODE at AC.

3-2-2-9. Disconnect lead from Calibrator.

3-2-2-10. Connect a sinewave generator set for 1 KC sinewave of 5 volts amplitude to preamplifier INPUT A.

3-2-2-11. Turn SYNC LEVEL control fully clockwise. Turn STABILITY control fully clockwise. The sweep will now free run.

3-2-2-12. Turn the STABILITY control counter-clockwise until the sweep stops.

3-2-2-13. Turn the SYNC LEVEL control counter-clockwise to synchronize the signal. Note that by changing the position of the SYNC LEVEL control the level where the sweep starts will change. This allows selection of the desired trigger level. The STABILITY control determines the sensitivity of the trigger circuits. Lower level input signals will require setting the STABILITY control further towards the free running condition (clockwise).

3-2-2-14. Turn the TIME/DIV switch to other settings. Note that the sweep time changes by a factor of 10 between steps.

3-2-2-15. Turn the MAGNIFIER from 1 X to 5 X. Note that the sweep length increases by a factor of 5. It should be remembered, therefore, that the overall sweep time per division is divided by a factor of 5.

3-2-2-16. Turn the MULTIPLIER to various settings. Note that the time per division is multiplied by the factor selected. The VARIABLE control provides continuous (uncalibrated) adjustment between the MULTIPLIER steps. The sweep is calibrated with the VARIABLE control fully counter-clockwise.

3-2-2-17. Disconnect sinewave generator.

3-2-2-18. Proper adjustment of the ASTIGMATISM control is made with a stationary spot on the viewing screen. Turn the STABILITY control fully counter-clockwise. Turn the preamplifier INPUT selector switch to the — position. Carefully advance the INTENSITY control until a spot is visible. Adjust the FOCUS and the ASTIGMATISM controls simultaneously for the smallest possible round spot. Do not allow the stationary spot to remain longer than necessary to make this adjustment. Reset the INTENSITY control to its former position.

3-2-3. Storage Operation. Follow turn-on procedure given in the above paragraphs.

3-2-3-1. Set STORAGE control to NORM position.

3-2-3-2. While becoming familiar with the controls, it is important to keep the trace slightly out of focus to prevent a sharply focused spot of high intensity from remaining too long in one position, as this may damage the storage tube. Adjust the FOCUS control for a spot approximately 1/4" in diameter. Insure that the INTENSITY setting is no higher than necessary for normal viewing. Set the TIME/DIV switch to 1 second per division.

3-2-3-3. Turn the THRESHOLD control slowly in a clockwise direction until the MEMOTRON tube begins to store. Continue advancing the THRESHOLD control until the tube will retain the trace without fading. Advancing the THRESHOLD control beyond this point will not facilitate storage, but will merely increase brightness of background. Maintaining excessive background brightness over a long period of time can result in degradation of the delicate meshes in the MEMOTRON tube. In event of accidental excessive brightness, depress the ERASE button immediately and reduce brightness with the THRESHOLD control.

3-2-3-4. Slowly rotate the VERT POSITION control in opposite directions and observe storage of the trace over the various areas of the viewing screen.

3-2-3-5. Depress the ERASE button. Note that the stored area is erased. An external erase jack is also provided to facilitate remote operation or automatic programming of the erase feature. External erasure is accomplished by grounding the signal applied to the jack. Caution must be exercised when making connections to the external erase jack, as it carries the same voltage potential as the storage mesh, which may be as high as 370 volts through a 68K impedance.

3-2-3-6. Storage Fast. Note the STORAGE FAST position. This mode is extremely useful for storage of "one-shot" signals of high frequencies. This mode should not be required for sweep speeds below 100 usec/div, unless dictated by signal characteristics. The FAST mode of operation should be restricted to single sweeps, as repetitive signals will tend to integrate and to flood the background.

3-2-4. Single Sweep. Single sweep operation is best demonstrated while the instrument is in the Storage Mode so the fast moving single trace will be stored for visual operation.

3-2-4-1. Follow the Turn-On Procedure given in previous paragraphs. Turn the SWEEP switch to SINGLE. Turn STABILITY control fully clockwise. The sweep will now be free running.

3-2-4-2. Turn the STABILITY control counter-clockwise until the sweep stops. (Stability Indicator Light goes out).

3-2-4-3. Turn SWEEP switch to RESET. If RESET light does not remain lighted, continue to turn the STABILITY control counter-clockwise until the RESET light remains lighted when the SWEEP switch is turned to the RESET position and released.

3-2-4-4. Turn the STORAGE control to NORM. Increase the THRESHOLD (red knob) to the point where the tube is known to store.

3-2-4-5. Connect a sinewave generator to the preamplifier INPUT
A. Set the sinewave generator for 1 KC signal, with the output level at zero.

3-2-4-6. Slowly increase the output amplitude of the sinewave generator until the oscilloscope triggers and a stored trace is observable on the viewing screen. Note that further changes in amplitude of the sinewave generator will not trigger the oscilloscope again until the RESET switch is reactivated. Depress the ERASE button.

3-2-4-7. Reduce the amplitude of the signal generator to zero. Turn the SWEEP switch to NORM. Repeat the above step with various settings of the STABILITY and SYNC LEVEL controls. Note that setting of these controls determines the signal amplitude required to trigger the oscilloscope.

3-2-5. Calibrator. The Calibrator circuit provides a square wave at a front panel connector which is useful in adjusting square wave response of probes or other attenuators. It is also useful to set amplifier gain. This accurately calibrated waveform is clamped to ground, and rises positively from ground. The frequency of the calibrator output is approximately 1 KC. The CALIBRATOR black knob can be set for a square wave of selected amplitude and the red knob selects volts, millivolts and OFF.

3-2-6. External Blanking. External blanking of the writing beam can be accomplished by injecting a signal of zero to +10 volts amplitude through the d-c coupled EXT BLANK jack located in the recessed compartment on the front panel.

Since the external blanking signal will be non-delayed while the displayed signal will be delayed for .25 usec in the vertical amplifier, an apparent phase shift will result with high frequency signals. At low frequencies, the delay time will be of no consequence.

3-2-7. + Gate. An output jack located in the recessed compartment on the front panel provides a cathode follower output in the form of a rectangular positive-going waveform during the active portion of the sweep. The signal is referenced to ground and flips to an amplitude of 60 volts during the sweep. The + Gate output is useful in synchronizing the external equipment with the oscilloscope sweep generator.

3-2-8. Sweep Out. A front panel output jack provides a cathode follower output for the sweep sawtooth waveform. The signal is positive-going, rising from ground to a nominal amplitude of 150 volts. This output is useful in synchronizing external equipment with the sweep where switching functions are required at a predetermined level of the sawtooth.

3-2-9. External Sweep. A d-c coupled external sweep input jack is available for external sweep sources. The jack is effective when the SYNC SLOPE switch is set to EXT SWP. The deflection sensitivity with the MAGNIFIER in the 5X position is 0.35 volts per division. With the MAGNIFIER in the 1X position, deflection sensitivity is 1.85 volts per division. The EXT SWEEP GAIN control (red knob) provides variable gain control through the horizontal amplifier. If the signal source introduced through the EXT SWEEP jack is referenced appreciably higher or lower than ground, a-c coupling is recommended.

3-2-10. X-Y Plotting. The storage-type oscilloscope has been found to be extremely useful in X-Y plotting. When plotting the output of analog computers and servo mechanisms, the need for much expensive recording equipment is eliminated. The fast writing

speed, convenient visual presentation, and ease of erasure lend themselves to this mode of operation. For most X-Y plotting applications, the frequency response of the vertical amplifier is sufficiently wide so that phase shift should not be incurred within the range of writing speed in the storage mode (1,000,000 inches/sec.) With the proper gain settings, frequencies up to 100 KC can be plotted with negligible phase shift, using the front panel input jacks in the normal manner.

3-2-10-1. Plotting Frequencies Above 100KC. If signal frequencies above 100KC are fed through the normal inputs, a phase shift, due to differences in bandwidth of the vertical and horizontal amplifiers and also due to the vertical delay lines, will result in errors of positioning. This problem can easily be overcome by introducing the signals directly to the deflection plates through the pins located on the neck of the MEMOTRON tube. The deflection plates should be referenced to their normal operating potential of + 270 volts. The deflection sensitivity of the MEMOTRON tube is nominally 30 volts $\pm 5v$ per inch for the horizontal plates and 25 volts $\pm 5v$ per inch for the vertical.

3-2-11. Measurement of Low Frequency Signals. At very low frequencies, i.e. from d-c to a fraction of a cycle, a d-c shift measureable as overshoot or undershoot may be observed. This effect is caused by a drop in transconductance of the amplifier tubes when operated at very low frequencies. To overcome this effect, refer to Section VI, paragraph 6-13 of this manual.

Operating Hints. Having carefully followed the instructions given in the preceding paragraphs, the operator should now be familiar with the operation of the MEMO-SCOPE Oscilloscope, Model 105A. The following precautions should be observed when using the instrument to insure proper operation and optimum results.

INTENSITY Control. Do not turn this control beyond the point where the trace is adequately lighted for normal viewing, or to the point where a spot appears when the sweep is stopped. Maintaining high intensity over a long period of time may cause permanent damage to the MEMOTRON tube. Damage due to operator error is not covered by the warranty.

FOCUS Control. While familiarizing new personnel with the use of the instrument or when performing operations where a sharply focused line is not required, it is desirable to keep the trace slightly out of focus. This will cause the writing beam to be spread over a larger area and diminish the possibility of storage tube damage at very low sweep speed or if the sweep is stopped.

THRESHOLD Control Do not advance the THRESHOLD control beyond the point required for adequate storage. This will prevent undue increase of brightness of background, thus adding to the useful life of the tube. In event of accidental excessive background brightness, depress the ERASE button immediately and re-adjust the THRESHOLD control.

Leads and Probes. Low level signals require the use of shielded input leads. Leads should be kept as short as possible to minimize undesirable pickup. Loading may be reduced by use of compensated probes. The Hughes Oscilloscope Probe, Model A-106420, greatly reduces capacitive loading. These probes attenuate the incoming signal by a factor of 10 while increasing the input impedance to 10 megohms shunted by 10 uuf.

3-2-12. Phenomena Peculiar to Storage Tubes. The following effects may be observed with certain storage tubes. These effects are usually not harmful to the tube and will not affect operation of the instrument in any manner.

Sharply defined, brilliantly lighted hair-like lines of approximately 1/8th to 3/8th inches in length may be observed within the writing area. Although these lines will not store nor affect tube operation in any manner, their presence is an indication that the storage threshold circuit is being operated at a level in excess of that required for proper storage. Decreasing the storage threshold by means of the THRESHOLD control will minimize this effect.

Certain storage tubes, when new, exhibit tiny, aperiodic evanescent shadows caused by microscopic particles passing between the flood gun and storage mesh. The shadows will not store nor erase a stored image and will have no deleterious effect upon the tube or its operation. As the new tube is used, these microscopic particles eventually affix themselves to one of the tube elements and the shadows are eliminated.

Bright pinpoints of light may be visible for a short time after power has been removed and may reappear a few seconds after power is applied. These spots, usually less than .020 inch in diameter are caused by field emission within the tube and may be safely disregarded.

If spots larger than 1/4 inch appear about the periphery of the tube, it should be returned to the factory for repair to avoid permanent damage to the storage mechanism.

It is important that the Ion Repeller Circuit be fully operational at all times. An open circuit in the Ion Repeller Circuit can cause permanent damage to the MEMOTRON tube. The condition is usually apparent as a large oval shaped area in the center of the tube, with no

storage possible in the outer areas. If this condition is observed, switch the instrument to STORAGE OFF at once. Check bulb and cap connector #4 at the front end of the MEMOTRON tube for the proper voltage (approx.+420 volts.)

Maintaining the threshold level in excess of the minimum required for proper storage, prolonged storage, and continuous writing of the same stored waveform over the same area of the viewing screen may degrade the writing speed.

SECTION IV CIRCUIT DESCRIPTION

4-1. Block Diagram. (See Dwg. A106900). The Block Diagram indicates the interrelationship of the various circuits used in the MEMO-SCOPE Oscilloscope, Model 105A. The following descriptions give a brief explanation of the function of each circuit.

4-2. Vertical Deflection System. The Main Vertical Amplifier operates in conjunction with an interchangeable plug-in preamplifier. To increase the versatility of the instrument, a series of plug-in preamplifiers has been developed.

In general, this manual has been prepared for operation of the oscilloscope with the 05-1 Wideband, General Purpose Preamplifier. Specific information regarding other preamplifiers can be obtained from the respective instruction manual. A brief description of the available preamplifiers is given in Section II.

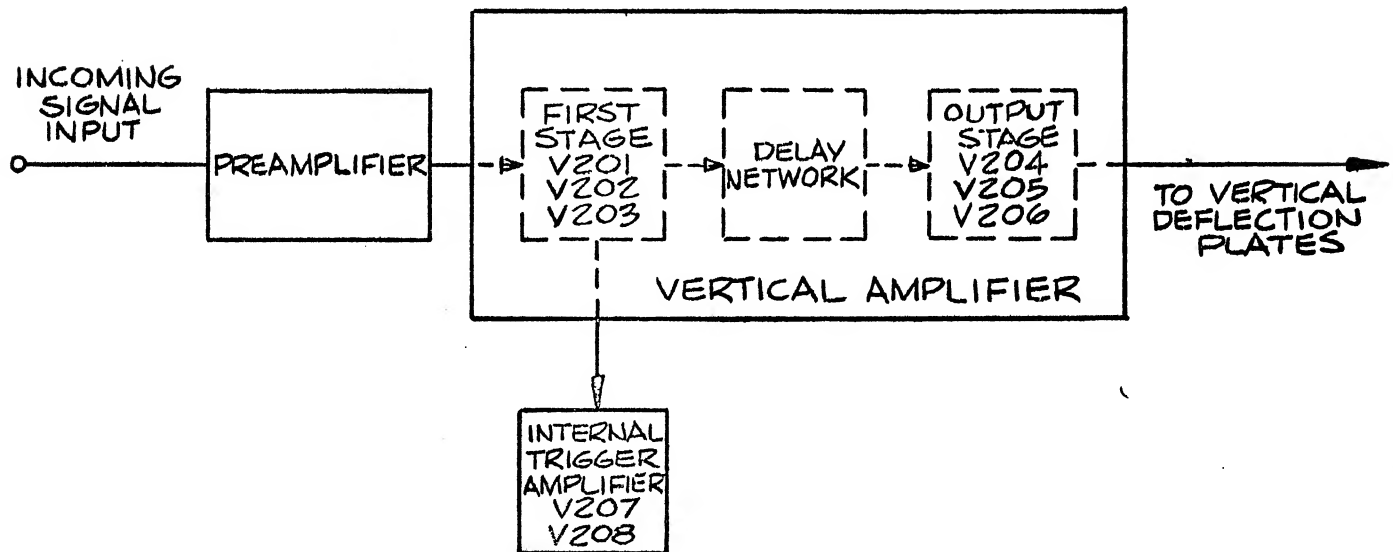


Figure 4. Vertical Deflection System.

4-2-1. Vertical Amplifier. (See Dwg. A-106902). The Vertical Amplifier is a direct-coupled, wide-band push-pull amplifier. It consists of a first amplifier stage, a delay network and an output amplifier stage. A pick-off from the input to the delay network provides a signal for internal triggering of the oscilloscope. The circuit has been factory adjusted to provide a full scale (10 division) vertical deflection of the writing beam with an input signal of 1.6 volts peak-to-peak, push-pull.

The first stage consists of a pair of pentodes V201, V202 connected for push-pull operation. Potentiometer R205 (screwdriver adjust) sets the gain of the vertical amplifier. Compensated plate and screen grid circuits improve frequency response. First stage output passes through cathode followers V203A-V203B, which drive delay network Z201, Z202. Cathode followers V204A-V204B reduce capacitive loading of the delay network. The delay network provides a 1/4 microsecond delay to prevent the incoming signal from reaching the vertical deflection plates of the MEMOTRON tube until the horizontal sweep is started.

V204 drives the output amplifier stage, V205, V206. Output of the final stage passes directly to the vertical deflection plates of the MEMOTRON tube. Potentiometer R212 (AMPL. BAL. ADJ.) located in the input circuit of V203, compensates for any difference between the d-c plate voltages in V205 and V206.

The signal for internal triggering is taken from the input to the delay network and amplified by the differential amplifier V207B-V208B. The differential amplifier insures constant amplitude of the a-c trigger signal regardless of change of setting of the vertical positioning control. V207A and V208A isolate the output of the differential amplifier from the capacitive loading of the wiring leading to the Trigger Amplifier Circuit. R246 provides adjustment of the d-c trigger level to zero volts when no input signal is fed to the amplifier. Front panel indicator lights I201 and I202 indicate the vertical positioning of the trace on the viewing screen.

At very low frequencies, i.e. from d.c. to a fraction of a cycle, amplifier transconductance will drop, affecting the vertical gain. This effect is compensated for by increasing the output amplifier plate load at the lower frequencies. Plate load resistor R238 is shunted by R259-C212B, and R241 is shunted by R257-C212A. Potentiometer R258 (D.C. Shift Comp.) varies the reactance of the R-C combinations to achieve the proper level between a-c and d-c gain.

4-3. Horizontal Deflection System. (See Dwg. A-106903) The Horizontal Deflection System consists of three major circuits, a Trigger Amplifier, Sweep Generator and Horizontal Amplifier. A separate Z-Axis Circuit provides for unblanking during the active portion of the sweep.

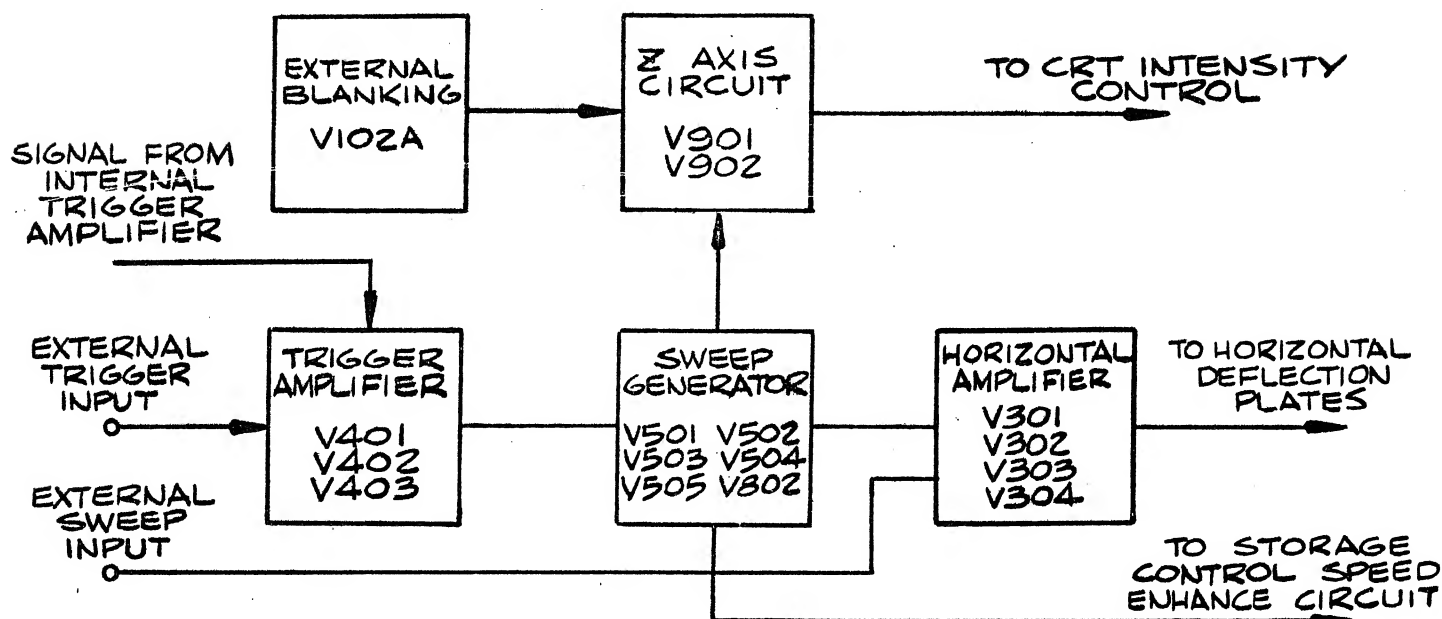


Figure 5. Horizontal Deflection System.

4-3-1. Trigger Amplifier Circuit. (See Dwg. A-106904). The Trigger Amplifier Circuit consists of a differential amplifier, the first Schmitt Trigger and switching circuitry to permit selection of triggering voltages. SYNC SLOPE (front panel) switch S401 selects the source and polarity of the triggering signal.

With S401 in the INT (internal) position, the triggering signal is obtained as a pickoff from V208A, located in the main Vertical Amplifier Circuit. In the EXT (external) position, the triggering signal is obtained through the front panel input jack, J401.

SYNC MODE (front panel) switch S402 provides for selection of a-c or d-c modes.

4-3-1-1. Normal Sweep.

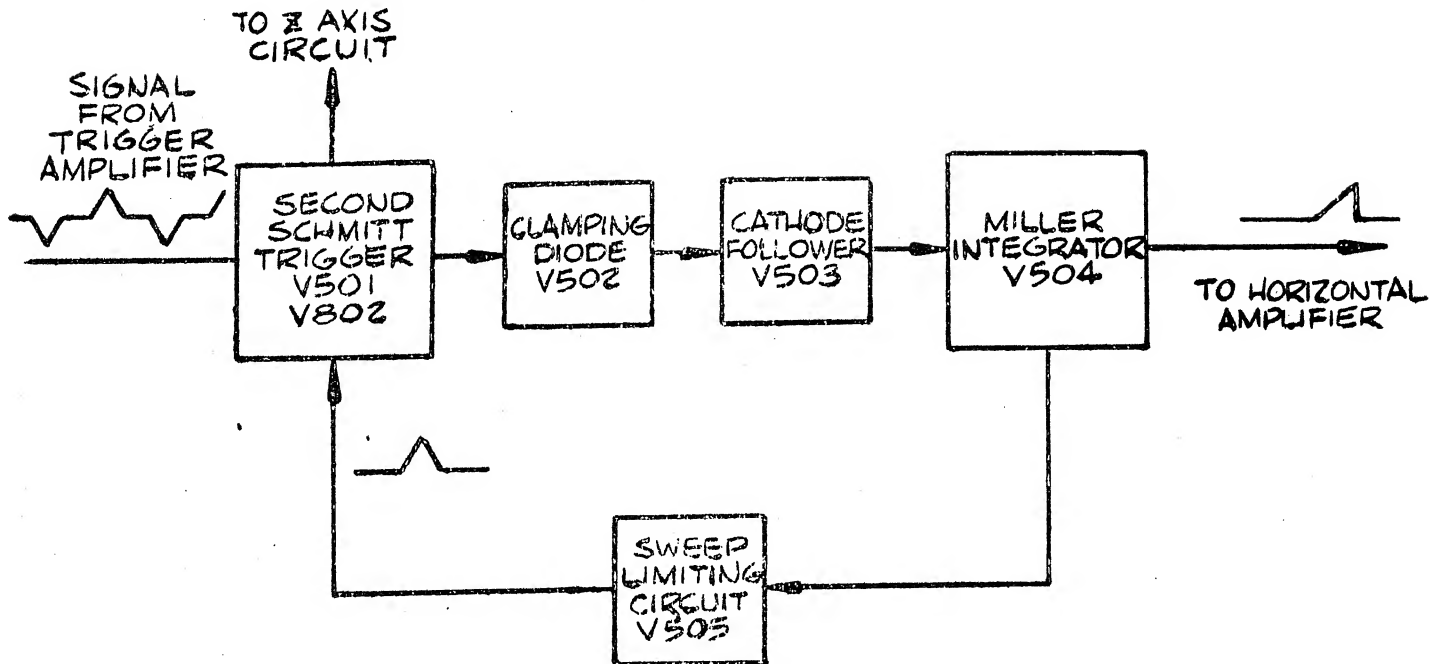


Figure 6. Sweep Circuitry (normal mode).

For normal sweep operation, SWEEP switch S403 (front panel) is set to NORM. S401 is set in the desired mode, and the triggering signal fed to differential amplifier V401. Selection of a rising or falling slope to trigger the sweep depends upon the setting (+ or -) of the front panel SYNC SLOPE switch. Triggering signals are fed to either the grid of V401A or V401B. V401A will trigger the sweep on a negative slope and V401B triggers on a positive slope. L401 and L402 are shunt peaking and series peaking inductances for the improvement of high frequency response of the trigger amplifier.

The amplified signal at the plate of V401B is direct-coupled to the first Schmitt Trigger, V402. The level at this point is controlled by the SYNC LEVEL (front panel) control R411. When the plate level of V401B rises above approximately 138 volts, the plate level of V402B switches rapidly from +225 to +235 volts. When the signal drops below +133 volts, the plate level of V402B returns to +225 volts.

Differentiation due to capacitor C407 and resistor R502 (located in the Sweep Generator Circuit) results in sharp spiked pulses required for triggering the sweep generator.

4-3-1-2. Single Sweep. Single sweep, or "one shot" operation is accomplished by using a thyatron tube, V403, which prevents repetitive operation of the first Schmitt Trigger. When the thyatron is cut off (S403 in NORM position), the first Schmitt Trigger operates as described in paragraph 4-3-1-1. When the thyatron fires, the grid level of V402B is prevented from rising, which in turn, prevents further operation of the Schmitt Trigger.

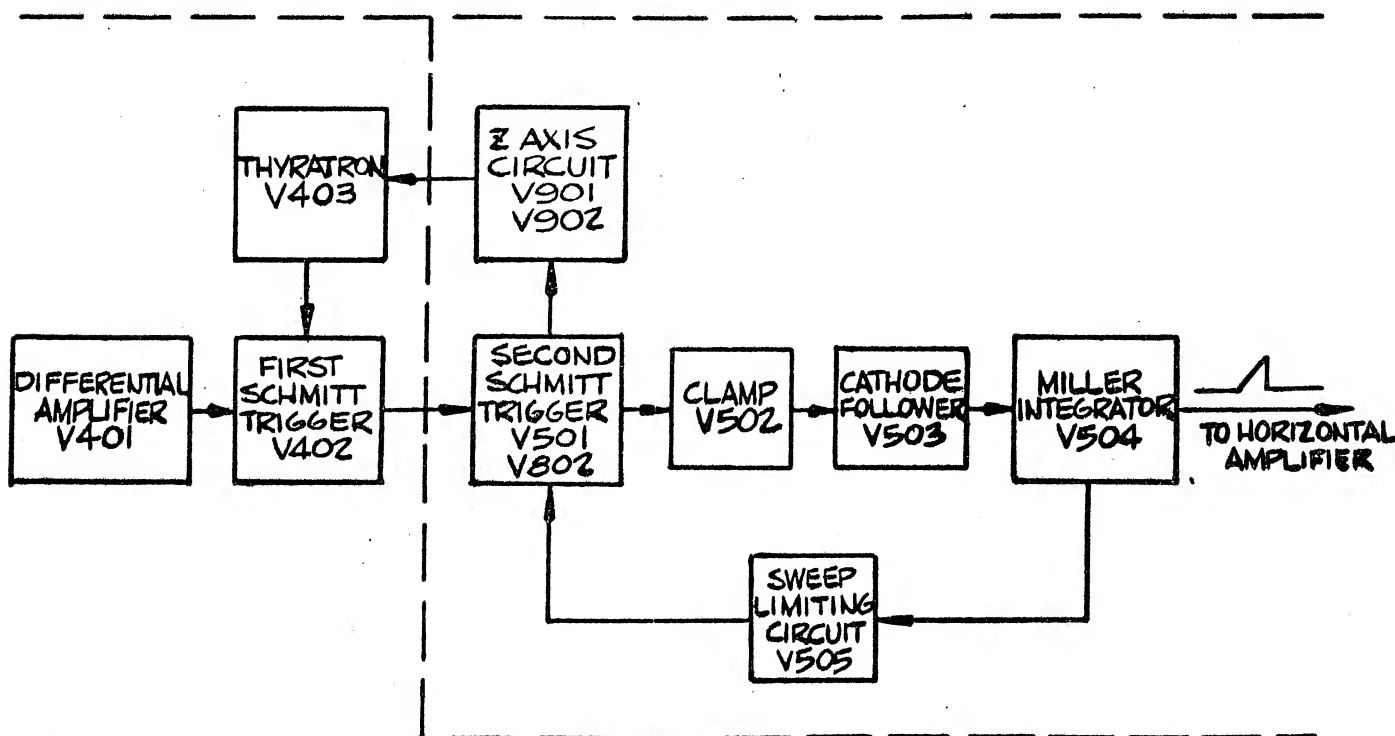


Figure 7. Sweep Circuitry (single sweep mode).

When the sweep starts, a positive pulse produced by differentiating the unblanking pulse received from the Z-Axis Circuit is applied to the thyatron grid. This causes the thyatron to fire, dropping its plate level from +170 volts to +20volts, which is far below that of the grid level of V402B, cutting off the first Schmitt Trigger. The sweep will remain inoperative until the front panel SWEEP switch, S403, is turned to the RESET position.

When S403 is turned to the RESET position, the plate level of V403 is dropped below the cathode potential, extinguishing the thyatron. When the switch is released from its spring-loaded RESET position, the plate level returns to +170 volts, and the thyatron is again in the "armed" or ready state.

4-3-2. Sweep Generator. (See Dwg. A-106905.) The main components of the Sweep Generator Circuit are the second Schmitt Trigger, V501-V802B, and a Miller Integrator, V504. The Sweep Generator can be triggered by a selected pulse or it may be operated in a free running mode. A sweep limiting circuit consisting of V505 and associated components controls the amplitude of the linear sweep.

4-3-2-1. Triggered Operation. In the triggered mode, the incoming trigger pulse from V402 in the Trigger Amplifier Circuit is fed to the grid of V501A. During normal operation of the second Schmitt Trigger, V501A is cut off and V501B is turned on. Potentiometer R509 sets the grid bias of V501B. A negative pulse fed to the grid of V501A causes the second Schmitt Trigger to switch so that plate level of V501B suddenly drops from -1 to -4 volts, cutting off the twin diode, V502. This allows charging of the appropriate capacitors in the RC combination R518-R520, C509-C514 for the sweep speed selected by the TIME/DIV switch, S501. Operation of the feedback circuit consisting of Miller Integrator V504 and cathode follower V503A causes the plate voltage of V504 to rise linearly. Cathode follower V802B is used in the second Schmitt Trigger between the plates of V501A and the grid of V501B to reduce switching time and to provide a low impedance output for the unblanking pulse.

A portion of the positive-going waveform at the output of V504 is sampled from the output of cathode follower V503B by the sweep length adjustment potentiometer R525. The sample from R525 feeds into cathode follower V505B. Output of V505B is fed to the grid of V505A. V505A is normally cut off during the sweep, but conducts when the sampled screen voltage applied to it overrides the cathode bias. The output of V505A is applied to V501A.

A waveform of sufficient amplitude applied to the grid of V501A will cause it to conduct, cutting off V501B. This causes the plate potential of V501B to rise from -4 to -1 volts, and V501B cuts off. Diode V502 now conducts since the anode is more positive than the cathode. When diode V502 conducts, the selected charging capacitor (C509-C514) discharges through V502, causing the grid voltage of

V504 to return to a fixed level. The plate voltage of V504 drops back to normal, stopping the sweep.

The RC time constant of the appropriate reset capacitor (C505-C508) delays the rate of fall on the input grid of the Schmitt Trigger, preventing a new sweep from starting before the charging capacitors are fully discharged.

The sweep multiplier (front panel switches S502-S503) control sweep duration by controlling selection of the charging voltages applied to the RC charging circuit. The multiplier operates on the principle that the sweep duration is inversely proportional to the charging voltage applied to the RC circuit. For example, when the front panel TIME/DIV switch is set at 1 microsecond per division, and the MULTIPLIER switch at 9, the sweep rate will be 9 microseconds per division. The voltage source must be of constant impedance to insure accurate sweep rates with the MULTIPLIER switch in any position. Resistance network R535-R541 compensates for effective resistance variation due to multiplier switching. Potentiometer R551 provides continuous adjustment between the sweep multiplier steps when S503 is in the VARIABLE position. Its exact range is set by R552.

An adjustable negative voltage equal to the resting potential of the Miller Integrator grid is applied to the junction of R548 and R552 to provide a common referenced level for the multiplier and charging circuit. The voltage is derived from the full wave rectifier which supplies relay K602 in the Low Voltage Power Supply Circuit. The voltage level is set by potentiometer R634, which is mounted on the Low Voltage Rectifier Board.

Dual cathode follower V503 provides low impedance outputs. Output of V503B is fed as a sweep signal to the Horizontal Amplifier Circuit. Output of V503A is fed to a front panel jack (J501) as a "sweep out" signal.

4-3-2-2. Free Running Operation. During normal operation as described in paragraph 4-3-2-1 above, V505A and V505B control resetting of the second Schmitt Trigger. The STABILITY (front panel) control, R513, permits free running of the sweep by setting the grid bias of V501A at a potential sufficiently low for the plate level of V501B to switch to -4 volts. This permits the sweep speed capacitors to begin charging. Charging continues until the positive-rising waveform fed back to the grid of V501A drives the grid sufficiently positive to stop the sweep. This, in turn, causes the grid level of V501A to drop sufficiently for the sweep to start again.

In the free running mode, the sweep generator can be synchronized with incoming trigger pulses from the Trigger Amplifier Circuit. This will permit synchronization with signals of a higher frequency than can be used for normal triggering.

4-3-3. Horizontal Amplifier. (See Dwg. A-106903). The Horizontal Amplifier is a direct coupled amplifier with a push-pull output. The circuit provides proper voltages required for full horizontal deflection (10 divisions) of the MEMOTRON tube writing beam. Voltage output is of sufficiently low impedance for rapid sweep rates. The average d-c output level is held to approximately +270 volts. The circuit consists of three stages; an input cathode follower, a pentode differential amplifier, and output cathode followers. An additional cathode follower is used to set the d-c level of the second section of the differential amplifier.

The incoming signal from the Sweep Generator Circuit passes through a variable attenuator network to the grid of Cathode follower V301A. C301 provides for frequency compensation of the input attenuator network. When the oscilloscope is operating in the internal sweep mode, S401A connects the cathode of V301A to the grid of V302.

When S401A is set in the EXT SWEEP position, V302 receives the input signal through potentiometer R307 (EXT SWEEP GAIN) control. R302 is used to set the overall gain of the Horizontal Amplifier when the oscilloscope is operated in the internal sweep mode.

The differential amplifier V302-V303 splits the signal into two phases for push-pull operation and develops sufficient voltage swing for full deflection of the writing beam. Output of V302 and V303 is fed to the grids of cathode followers V304A and V304B where the impedance of the sweep voltage is lowered sufficiently to drive the deflection plates. Since the rate of change for the negative-going cathode follower is limited by an RC time constant, the cathode resistor of V304A has one-half the resistance value of the cathode resistor of V304B. The negative excursion is also accelerated by means of feedback capacitor C304.

When the front panel MAGNIFIER switch is set a 1X, the cathodes of the differential amplifier are connected by R320. In the 5X position, R320 is shunted by R321, thus decreasing the cathode-to-cathode resistance and increasing the amplifier gain by a factor of 5.

Cathode follower V301B provides a low impedance source to set the grid level of V303. This level can be adjusted by the HORIZ POSITION

control so that any portion of the waveform in the center of the viewing screen will remain centered on either the 1X or 5X setting of the MAGNIFIER switch. R309 adjusts the level for the 5X position.

4-3-4. Z-Axis Circuit. (See Dwg. A-106909). The Z-Axis Circuit provides for unblanking of the MEMOTRON tube control grid during the active portion of the sweep. A positive pulse, coincident in time with the active portion of the sweep is fed from V802B in the second Schmitt Trigger to the Z-Axis differential amplifier V901A-V902A. The differential amplifier amplifies the pulse to obtain a 100 volt swing. The pulse is then passed through cathode follower V902B, and through a portion of the High Voltage Power Supply Circuit to the MEMOTRON tube control grid.

Capacitor C903 reduces the pulse rise time to avoid loss of presentation at the beginning of the sweep when fast sweep speeds are used. Rise time is further decreased by peaking coil L901.

The plate level of V901A rises sharply at the end of the sweep excursion. During single sweep operation of the oscilloscope, C901 and R901 differentiate the positive-going excursion, producing a spiked pulse. This pulse is fed to the grid of thyatron V403 in the Trigger Amplifier Circuit, firing the tube as described in paragraph 4-3-1-2.

The pulse at the cathode of V902B is fed through cathode follower V901B to the preamplifier input plug, J201. This pulse is used for switching the multivibrator in dual trace preamplifiers.

Cathode follower V901B provides a gating pulse to the front panel + Gate jack, J902.

J903 provides an input for external blanking signals to the grid of cathode follower V102A. Output of V102A passes to the grid of V902A through R908-C908. The cathode resistor R1309 is common to V102A and V1301B.

4-3-5. Dual Trace Blanking Circuit. (See Dwg. A-106913). To eliminate storage of the vertical components of the chopped waveforms and enable presentation of only the desired information, a separate blanking circuit is used in conjunction with the dual trace preamplifier.

The square wave output from the preamplifier multivibrator V10B-V11B is fed through the preamplifier plug, differentiated and passed to an "OR" Gate consisting of diodes D1301 and D1302 and associated resistors. The negative fall of each of the square waves passes through

the OR Gate to V1301A, where it is amplified. The positive pulse output of V1301A feeds cathode follower V1301B. This positive signal is fed to the grid of V902A in the Z-Axis Circuit and mixed with the normal unblanking gate.

4-4. Storage Circuits. (See Dwg. A-106901). Five circuits control the storage of information on the MEMOTRON tube screen. Certain elements in the storage tube require set voltages, while others require variable voltages or pulsed waveforms.

4-4-1. Speed Enhancement Circuit. Storage of high speed, single sweep traces is improved by application of a "speed enhancement" pulse to the flood gun cathodes. This pulse, which is operative only when the STORAGE switch S101 is in the FAST position, improves the ability of the MEMOTRON tube to store waveforms which require rapid writing speeds. Since the pulse tends to flood the viewing screen, it is used only in the single sweep mode.

Monostable multivibrator V101A-B provides a negative pulse of approximately 70 volts amplitude and 500 microseconds duration at the end of the sweep period. Because of minor tube variations, amplitude and duration of the pulse are factory adjusted for optimum performance of each individual MEMOTRON tube. Amplitude of the pulse is adjusted by potentiometer R105, duration is adjusted by R102. Diode D102 prevents the flood gun cathode potential from rising above +170 volts in the storage mode.

The incoming signal from the +Gate is coupled to the multivibrator through C101. At the end of the sweep period, the +Gate falls, and the negative fall is used to trigger the multivibrator. Diode D101 prevents positive pulses from reaching the grid of V101B.

In the non-storage mode, the flood guns are cut off completely to prevent residual currents from integrating and causing a blurred trace. The flood guns are cut off by setting the storage switch S101 at OFF, which raises the cathode voltage of the flood guns to +270 volts, and sets the grid levels at -150 volts, obtaining a total negative bias of -420 volts.

4-4-2. Erase Circuits. In the storage mode, the MEMOTRON collector mesh voltage is adjusted by means of the STORAGE THRESHOLD control R111, and resistors R110 and R112 to provide optimum storage level during writing. Erasure of the stored information is accomplished by lowering the collector mesh voltage to about flood gun cathode potential. This is done by depressing the front panel ERASE button. Erasure can also be accomplished by grounding the external erase jack, which drops the collector mesh potential through R119 and R123. Diode D105 prevents the collector mesh potential from falling below +170 volts.

4-4-3. Collimation Control. Collimation of the flood gun patterns is accomplished by varying the voltage on the flood gun control grids of the MEMOTRON tube. The two patterns are adjusted for uniform screen coverage by potentiometer R108, which is factory set.

4-4-4. Ion Repeller Mesh. The voltage level on the ion repeller mesh is adjusted by potentiometer R125, which is factory set for optimum tube performance.

4-4-5. Contrast Enhancement. Contrast enhancement (darkened background of viewing screen) is provided by injecting a small positive pulse on the storage mesh. The pulse is obtained from V802 in the Calibrator Circuit. The contrast enhancement pulses decrease the maximum writing speed if applied during the sweep, therefore it is necessary to remove the pulses from the mesh prior to and during a "one shot" sweep. During single sweep operation, the pulses are blocked by diode D103, which is back-biased through R114. At the end of the "one shot" sweep, the pulses are passed automatically and are present during all other modes of operation.

Resistor R113 and an a-c coupling network consisting of C106, R117, R118 and D103 couple the calibrator waveform to the grid of cathode follower V102B. R114 is connected to the plate circuit of single sweep thyatron V403, located in the Trigger Amplifier Circuit.

After the thyatron V403 has been fired by the sweep circuitry, the d-c level at the junction of R114 and R117 drops, and the calibrator square wave is passed to the grid of cathode follower V102B, then through differentiation network C108 and R128 to the storage mesh.

The pulse amplitude is factory set by R118 for optimum results. A typical waveform is of approximately 12 volts amplitude with a nominal 10 microsecond width. Diode D106 clamps the storage mesh to +170 volts so that it cannot drop below this level in event of component failure.

4-5. Calibrator. (See Dwg. A-106908). The Calibrator Circuit generates square waves of approximately 1 KC which are used in adjusting the sensitivity of the vertical amplifier. The square waves are also useful for frequency compensation of probes and attenuators.

The calibrator consists of free running multivibrator V801A-V801B, cathode follower V802A and a step attenuator.

Output of the multivibrator, taken at pin 6 of V801B, passes through the attenuator C803, R807 to the grid of V802A. Positive excursion above plus 100 volts is prevented by clipper diode D801; negative excursion below zero volts is prevented by the cathode follower. Output amplitude is adjusted by potentiometer R809. Switch S801 provides selection of output levels in volts, millivolts, or OFF. Switch S802 provides step attenuation from 0.2 millivolt through 100 volts, peak-to-peak.

It should be observed that, due to the variable internal impedance of the calibrator, calibration is accurate only with high impedance loads.

4-6. Power Supplies. The power supplies which provide the voltages required by the oscilloscope circuits are electronically regulated for stability of operation and accurate calibration. Solid state rectifiers are used in both the high voltage and low voltage power supplies. Protective circuitry in the high voltage supply prevents damage to the MEMOTRON tube by limiting bias in event of component failure.

4-6-1. Low Voltage Power Supply. (See Dwg. A-106906). Transformer T601 furnishes all plate and heater voltages required by the oscilloscope and the preamplifier. The primary of T601 consists of two separate 117 volt windings which can be connected in parallel for 117 volt operation or in series of 234 volt operation. The secondary consists of six separate high voltage windings and six separate low voltage windings. High voltage outputs are rectified by five silicon rectifier full-wave bridge circuits and by a voltage doubler. Available outputs are +500v, +400v (unregulated), +360v, +270v, +170v, +100v, -150v, and -48 v. The +500v, +360v, and -150v are factory adjusted for optimum performance of the oscilloscope.

A time delay relay, K601, provides a 30 second filament warm-up period before application of the +400, +360, +270 and +170 voltages to the oscilloscope circuits. At the end of the warm-up period, relay K601 energizes relay K602, which closes contacts to the respective secondary windings of T601.

The -6 volts required by the time delay relay K602 is taken from terminals 17 and 19 of T601, rectified by diodes D623 and D624, and filtered by capacitor C612.

The -6 volt supply is also fed through voltage divider network R633, R634 (variable) and R635. Capacitor C615 provides additional filtering. R634 adjusts the voltage to approximately -2 volts, which is fed to the sweep multiplier circuit to insure accurate sweep length in the event of variations in line voltage.

4-6-1-1. Low Voltage Regulation. All outputs of the Low Voltage Power Supply except the +400 v are regulated by referencing each voltage to the -150 volt supply.

4-6-1-2. -150 Volt Reference Voltage. The -150 volt supply is taken from terminals 13 and 14 of transformer T601 and rectified by bridge rectifier circuit D615-D618. The -150 volt supply is referenced to the gas filled regulator tube V611, which sets the grid bias of V612A. The grid bias of V612B is determined by voltage divider network R646, R647 (variable) and R648. R647 permits accurate setting of the -150 volt bus. The difference between the two grid levels of V612 appears as an error signal at the plate of V612A. The error signal is amplified by V605 and applied to the grids of series regulator V610. Any variation in voltage on the -150 volt bus is corrected by the feedback network consisting of V605, V610 and V612.

4-6-1-3. +170 Volt Supply. The +170 volt supply is taken from terminals 11 and 12 of transformer T601 and rectified by bridge rectifier circuit D611-D614. A portion of the output is passed through the voltage divider network R624 and R630. The voltage divider is referenced to -150 volts, and sets the grid level of V604 at approximately zero volts. Any change in this level appears as an error signal on the grid of V604. This error signal is amplified and applied to the grid of series regulator V609, which maintains constant output during changes in load. Capacitor C610 improves the high frequency response of the regulator.

4-6-1-4. +100 Volt Supply. The +100 volts is taken from the output of the regulated +170 volt supply. A portion of the output is passed through voltage divider network R641-R652, which is referenced to -150 volts and sets the grid level of V613B at approximately -5 volts. Any change in level appears as an error signal on the grid of V613B. This error signal is amplified and applied to the grid of series regulator V613A, which maintains constant output during changes in load. Capacitor C621 improves the high frequency response of the regulator.

4-6-1-5. +270 Volt Supply. The +270 volt supply is taken from terminals 9 and 10 of transformer T601, rectified by bridge rectifier circuit D607-D610, and added to the output of the +170 volt supply.

A portion of the output is passed through voltage divider network R625 and R629. The voltage divider is referenced to -150 volts and sets the grid level of V603 to approximately +170 volts. Any change in output appears as an error signal on the grid of V603. The error signal is amplified and applied to the grid of series regulator tube V608, which maintains constant output during changes in line load. Capacitor C609 improves high frequency response.

4-6-1-6. +360 Volt Supply. The +360 volt supply is taken from terminals 7 and 8 of transformer T601, rectified by bridge rectifier circuit D603-D606 and added to the +270 volt supply. A portion of the output is passed through voltage divider network R636, R637 (variable) and R638. R637 permits adjustment of the vertical deflection plate level to average +270 volts. The voltage divider is referenced to -150 volts, and sets the grid level of V602 at approximately +170 volts. Any change in output appears as an error signal on the grid of V602. The error signal is amplified by V602 and applied to the grid of series regulator tube V607, which maintains constant output during changes in load. Capacitor C613 improves high frequency response by compensating the voltage divider.

4-6-1-7. +400 Volt Supply. The +400 volt unregulated supply is obtained from the +270 volt supply bridge rectifier circuit. Filter network C616A, C616B and R640 lowers the output impedance and minimizes ripple. Since the +400 volt supply is unregulated, output may vary between +380v and +420v, depending upon changes in line voltage.

4-6-1-8. +500 Volt Supply. The +500 volt supply is obtained by passing the output from terminals 5 and 6 of transformer T601 through a voltage doubler consisting of D601, C601, D602 and C602. A portion of the output is passed through voltage divider network R626, R627 (variable) and R628. R627 permits adjustment of the horizontal deflection plate level to average +270 volts. Capacitor C608 improves high frequency response. The voltage divider is referenced to the -150 volt bus and sets the grid level of V601 at approximately +270 volts. Any change in output appears as an error signal on the grid of V606, which maintains constant output during changes in load.

4-6-1-9. -48 Volt Supply. The -48 volt regulated supply is obtained by passing the output of pins 15 and 16 of T601 through bridge rectifier circuit D619-D622. Voltage divider network R649-R650, which is referenced to the -150 volt supply, is fed to the base of emitter follower Q602, setting the level of the output voltage. Q602 provides a base current for

emitter follower Q601. Capacitor C620 aids in minimizing ripple. The main function of the -48 volt supply is to furnish d-c filament voltages required by the oscilloscope preamplifiers.

4-6-2. High Voltage Power Supply. (See Dwg. A-106907). High voltages required for accelerating and focusing the writing gun beam are furnished by an RF oscillator operated at a frequency of approximately 75 KC. The output of oscillator V701 is stepped up by transformer T701.

The 4KV required by the viewing screen of the MEMOTRON tube is taken from pin 7 of transformer T701 and rectified by diodes D702 and D704. Filter capacitor C711 minimizes ripple.

The -1.65KV required by the writing gun grid is taken from a separate winding terminal of T701 to enable d-c coupling of the unblanking pulse to the writing gun grid. The current is rectified by diode D701.

The -1.45KV required for the writing gun cathode is taken from pin 8 of T701 and rectified by diode D703.

4-6-2-1. Voltage Regulation. High voltage regulation is maintained by a feedback system which samples the voltage taken from the terminal of the writing gun cathode through voltage divider network R710, R711, R706, and R707. D-c amplifier V702 controls the output of oscillator V701 by varying the screen voltage. High voltage output is set by potentiometer R707, which adjusts the grid bias of V702B.

4-6-2-2. Writing Beam Intensity. Writing beam intensity is adjusted by potentiometer R712. R712 shifts the d.c. level of the writing gun grid, since it is connected to the cathode of the unblanking cathode follower V902B in the Z-axis circuit (see Dwg. A-106909.)

4-6-2-3. Unblanking. Unblanking voltages are obtained by shifting the level of the grid supply through cathode follower V902 in the Z-Axis Circuit and voltage divider network R712, R713, and R714. Capacitors C714 and C715 aid the fast rising unblanking pulses in reaching the writing gun grid and provide rapid turn-on and turn-off of the writing gun beam.

4-6-2-4. Focusing. The voltage required by the focusing electrode is obtained from the cathode supply through voltage divider network R718, R719, and R720. Variable resistor R718 provides for focus adjustment.

4-6-2-5. Protective Features. The High Voltage Power Supply incorporates a special feature to insure safe operation of the delicate components within the storage tube. Diode D705 clamps the writing gun grid supply through potentiometer R715 and neon lamp VR701. R715 is factory set to maintain a slightly negative bias between the writing gun grid and writing gun cathode if the grid supply should fail. Intensity of the writing beam is thereby prevented from rising above a safe value.

It must be remembered, however, that a well focused, stationary beam, set at a high intensity can still burn the delicate collector mesh. The time required to cause an actual burn in the collector mesh will vary slightly in accordance with the parameters of each individual storage tube. For safe operation, the INTENSITY control should not be set beyond the point required for a properly illuminated trace.

SECTION V MAINTENANCE AND SERVICE

5-1. Replacement of Components. Most of the electronic components required for replacement in the MEMO-SCOPE Oscilloscope, Model 105A, are available at all electronic supply houses. Complete parts lists will be found in Section VII of this manual. All non-standard components are marked with an asterisk in the parts list. Instructions for ordering non-standard components direct from Hughes are included in Section VII.

A separate parts list has been prepared for use with each schematic diagram. Components are referenced to schematic diagrams by number, e.g. all components numbers listed on Dwg. A-106901 will begin with the number 1; all component numbers listed on Dwg. A-106902 will begin with the number 2, etc. The parts lists also indicate the physical location of each component, e.g. the printed circuit board number, front panel switch number, etc.

5-2. Soldering. Normal precautions for soldering on printed circuit boards should be observed. Ceramic terminal boards will be found in some of the preamplifiers. When replacing components connected to ceramic terminal boards, the solder used must contain at least 4% silver. Silver-bearing solder is available at most electronic supply houses. Use of ordinary tin-lead solder will dissolve the bond adhering to the ceramic material and will damage the terminal board.

5-3. Disassembly.

5-3-1. To Remove Side Covers. Remove the 4 fasteners on each side and draw covers out of the channels.

5-3-2. To Remove Bottom Plate. Remove the rubber feet and the center holding screw. Remove plate.

5-3-3. To Remove Rear Panel. Remove the 2 fasteners from the air filter holder. Remove the 4 panel screws.

5-3-4. To Remove Carrying Handles. Lift cover plates at each end of handle. Remove the 3 screws at each end.

5-3-5. To Remove MEMOTRON Tube.

CAUTION

DO NOT HOLD THE MEMOTRON TUBE WITH THE VIEWING SCREEN FACE DOWN. KEEP SCREEN FACE UP OR TUBE IN HORIZONTAL POSITION TO PREVENT POSSIBLE DAMAGE TO THE STORAGE MESHES.

5-3-5-1. Remove the 4 screws holding the bezel and graticule.

5-3-5-2. Carefully unplug the socket from the base of the tube.

5-3-5-3. Disconnect the 5 leads from the neck of the tube, noting their relative positions.

5-3-5-4. Disconnect the anode caps from the front of the tube, noting their relative positions.

5-3-5-5. Push the tube forward, sliding gently out through the front panel. Do not jar the tube against the side of the shield.

5-3-6. To Remove High Voltage Power Supply.

CAUTION

BEFORE ATTEMPTING ANY WORK ON THE HIGH VOLTAGE POWER SUPPLY, WAIT 15 SECONDS AFTER TURNING POWER OFF. THEN DISCHARGE THE FILTER CAPACITORS BY PRYING UP J1, LOCATED ON TOP OF THE SUPPLY AND SHORTING TO GROUND WITH A WELL INSULATED SCREWDRIVER. NEVER SHORT THIS LEAD WITH POWER ON OR DAMAGE TO THE MEMOTRON TUBE WILL RESULT!

5-3-6-1. Disconnect the Jones plugs from rear of supply and all pin jacks mounted on terminal board located on top of high voltage supply box.

5-3-6-2. Loosen cable clamp holding delay lines and swing delay lines out of way. Loosen (but do not remove) the 2 screws on the rear of the high voltage supply front cover. Remove the 2 front screws and slide the cover up and out. This will permit access to internal components without necessitating removal of the power supply box.

5-3-6-3. Remove the screws holding the bottom of the high voltage supply to the floor plate. Remove screw holding rear of supply to vertical amplifier bracket. Lift supply out through top of instrument.

5-3-6-4. Remove the 3 remaining screws at corners of rear cover. Rear cover can now be swung out to permit access to all components.

5-3-7. Swing-Out Circuit Boards. The Sweep Trigger-Horizontal Amplifier Board is mounted on a hinged frame which swings out at a 60 degree angle to permit access to the Storage Control and Low Voltage Rectifier Boards. Note that pin jacks J901, J1301, J302, and J303 must be disconnected before this board can be swung to the side. The Low Voltage Regulator Board (A-106791) swings up at a 90 degree angle to permit access to the components beneath. A swing-out catch on the frame rail will support the regulator board in the vertical position.

5-3-8. Storage Control Board. Four screws hold the Storage Control Board (A-106864) to the frame. All components on the board are accessible when the oscilloscope bottom plate is removed.

5-3-9. Low Voltage Rectifier Board. Rectifiers and other components mounted on the Low Voltage Rectifier Board (A-106863) can be replaced without removal of the board. All components are accessible when the oscilloscope bottom plate is removed.

5-4. Trouble Shooting. The following tables should prove helpful in eliminating many difficulties which might arise from malfunction of components. It must be remembered, however, that the MEMO-SCOPE Oscilloscope, Model 105A, is a complex electronic instrument with many interacting circuits. Before attempting any trouble shooting, insure that all operating instructions have been followed carefully. The circuit descriptions should be studied carefully, and all necessary precautions taken to preclude damage to the instrument and to protect human life.

Symptom

Possible Cause

Remedy

Fuse Blown

Replace with a 5 amp medium delay (3AG-SLO-BLO) fuse for 117 vac operation or 3 amp medium delay (3AG-SLO-BLO) fuse for 234 vac operation.

Low Voltage Power Supply Inoperative

Defective diode. Check D601-D622.
Defective filter or bypass capacitor. Check C601-C619.

Defective tube. V601-V613

Defective current limiting resistors. Check R601-R607.

Check for possible short circuit on circuit boards served by power supply.

Time Delay Relay Inoperative

Check Relay K601.
Defective diode. Check D623, D624
Check Filter capacitor C612.
Check relay K602.

(1) No Power

<u>Symptom</u>	<u>Possible Cause</u>	<u>Remedy</u>
(2) No Beam	Low Voltage Power Supply Inoperative	See (1)
	High Voltage Power Supply Inoperative	Defective tube. Check V701, V702.
	Spot positioned off-screen.	Adjust Centering controls.
	Z-Axis Circuit Inoperative	Defective tube, check V302, V303, V205, V206 Check for continuity of wires leading to deflection plates. Defective tube. Check V901A, V902A-B, V102A.
(3) Defocused Beam	Improper voltages at deflection plates, at interplate shield or at writing gun.	Check connections at neck of MEMOTRON tube. Check potentials at horizontal and vertical deflection plates with beam centered on screen. All deflection plates and interplate shield potentials should be the same. Check + 270 v supply and average voltage of deflection plates. Check for -1450v at MEMOTRON cathode.

<u>Symptom</u>	<u>Possible Cause</u>	<u>Remedy</u>
(4) No Sweep	Sweep Generator Inoperative (with STABILITY control fully clock-wise)	Defective tube. Check V501A-B V802B. Check V502, V503, V504, V505A-B.
(5) Sweep of Improper Length (with Proper Timing)	Improper operation of Generator Board	Check V505. Adjust R525 (see Calibration Procedure).
(6) Improper Timing of Sweep	Defective tube in Sweep Generator	Check V502, V503, V504.
	Improper Adjustment of Sweep Generator	Adjust R302. Readjust R525 for proper sweep length (See Calibration Procedure).
	Improper Gain of Horizontal Amplifier	Check V301, V302, V303, V304.
(7) Non-linear Sweep on Fastest Sweep.	Improper compensation of sweep generator, of Horizontal Amplifier.	Adjust C301, C304, C305 for linearity. Adjust C514 for proper slope. (See Calibration Procedure.)

<u>Symptom</u>	<u>Possible Cause</u>	<u>Remedy</u>
(8) No SYNC or erratic SYNC	Defective trigger amplifier tube	Check V401A-B, V402A-B, V403, V501, V502, V305, V802.
	Sweep switch set at "SINGLE"	Reset to NORM for repetitive sweep.
(9) No Internal SYNC	Defective trigger amplifier tube	Check V207, V208.
(10) Improper SYNC	Defective Diode	Check D401.
	Improper bias on 1st or 2nd Schmitt Triggers	See Calibration Procedure.
	+ 4KV Supply Inoperative	Check diodes D702, D704. Check R708. Check Plug P701. Check Connector #1 on V103.
(11) No Storage or No Storage in Outer Areas	Poor connection to MEMOTRON tube	Insure proper and secure connection of all bulb and cap connectors at front end of storage tube.
	Poor connection to IRM Poor Collimation.	See Calibration Procedure.

<u>Symptom</u>	<u>Possible Cause</u>	<u>Remedy</u>
(12) Background Illumination too high, stored traces not visible.	Faulty operation of Contrast enhancement	Check V801, V802A, V102B
	Collector mesh voltage too high, improper operation of THRESHOLD control	Adjust THRESHOLD control to minimum level required for storage.
	Incorrect operation of FAST storage.	The Speed enhance or FAST storage position should be used only for single-sweep operation. See Calibration Procedure for proper operation of speed enhance.
(13) No UnBlanking or No Gate Output	Defective component in Z-Axis Circuit	Check tubes V901, V902.
(14) Beam will not cut off	High voltage supply defective	Check D701
(15) No control over intensity with front panel control	Defective clamping Diode, improper bias on writing gun	Check D705
	Defective high voltage supply.	Check D701
(16) Intensity level not uniform as beam sweeps across screen.	Improper bias on writing gun causes slope on unblanking pulse	Adjust R715 in accordance with Calibration Procedure

<u>Symptom</u>	<u>Possible Causes</u>	<u>Remedy</u>
(17) No interchannel blanking in dual trace preamplifier	Defective dual trace. Blanking tube. -48v supply not regulated	Check V1301 Check Q601, Q602
(18) Magnitude of deflection changes when position of INTENSITY control is changed.	Improper regulation of High Voltage Power Supply	Check tubes V701, V702. Readjust high voltage level to -1450 volts.
(19) No Vertical Signal	Defective component in Vertical Amplifier System	Check all tubes in Vertical Amplifier and Preamplifier
	Preamplifier set at "Ground"	Insure that preamplifier input switch is set to proper channel.
	Preamplifier inoperative	Check F602. Replace with 8AG 3/4 ampere fuse.
(20) Preamplifier cannot be balanced Trace cannot be centered	Vertical amplifier improperly balanced	Check V201, V202. See preamplifier Manual. See Calibration Procedure for proper calibration of Vertical Amplifier
(21) Fading of Stored Trace	Improper potential on collector mesh.	Increase THRESHOLD level.

<u>Symptom</u>	<u>Possible Cause</u>	<u>Remedy</u>
(22) Partial Erase	Improper potential on collector mesh	Decrease THRESHOLD level. See Operating Procedure.
	Improper setting of contrast enhance	See Calibration Procedure.
(23) No erase	Defective erase push-button	Check button by grounding with EXT ERASE connector.
(24) Bandwidth down when using any preamplifier	-48 volt supply not regulated	Check Q601, Q602. Insure -48 output ripple does not exceed 25 M.V.
	Misaligned Vertical Amplifier.	See Calibration Procedure

5-5. Voltage Measurements. The voltage readings indicated on the following tables were measured between tube pin and chassis ground with a vacuum tube voltmeter. A Model 05-1 Wideband Preamplifier was used with no signal input. The oscilloscope was connected to a line voltage of 117 volts, 60 c.p.s. and the front panel controls set as follows:

INTENSITY - fully counter-clockwise.
 TIME/DIV - 1 millisec.
 MAGNIFIER - 1 X.
 SYNC SLOPE - INT.
 SYNC MODE - a-c
 MULTIPLIER - 1X.
 VARIABLE - fully counter-clockwise.
 SYNC LEVEL - fully counter-clockwise.
 STABILITY - fully counter-clockwise.
 SWEEP - NORM
 HORIZ POSITION - spot in center of graticule.
 EXT SWEEP GAIN - fully counter-clockwise.
 STORAGE - FAST.
 THRESHOLD - fully counter-clockwise.

05-1 Wideband Preamplifier

INPUT - Grounded (not signal input).
 VERT POS - Spot in center of graticule.

Storage Circuit Board A-106864

Measure between Tube Pin and Ground	1	2	3	4	5	6	7	8	9
V101	360	-46	0	fil.	fil.	24	-.4	0	fil.
V102	170	0	7	fil.	fil.	170	-47	-33	fil.

Vertical Amplifier Circuit Board A-106790

Measure between Tube Pin & Ground	1	2	3	4	5	6	7	8	9
V201	58	54	fil.	fil.	140	168	59	---	---
V202	58	59	fil.	fil.	140	168	59	---	---
V203	270	140	140	fil.	fil.	270	140	140	n. c.
V204	360	124	128	fil.	fil.	360	124	128	n. c.
V205	130	128	130	fil.	fil.	fil.	270	280	130
V206	130	128	130	fil.	fil.	fil.	270	280	130
V207	240	240	360	fil.	fil.	142	140	270	240
V208	240	240	360	fil.	fil.	144	140	270	270

Horizontal Amplifier Circuit Board A-106867

Measure between Tube Pin & Ground	1	2	3	4	5	6	7	8	9
V301	270	-0.38	8.5	fil.	fil.	270	-27	-15	n. c.
V302	10	8.5	10	fil.	fil.	fil.	260	170	10
V303	-11	-15	-11	fil.	fil.	fil.	260	170	-11
V304	500	260	270	fil.	fil.	500	260	270	fil.

Sweep Circuit Board A-106867

Measure between Tube Pin and Ground	1	2	3	4	5	6	7	8	9
V401	144	7	10	fil.	fil.	170	0	10	n. c.
V402	242	170	172	fil.	fil.	270	155	170	n. c.
V403	0	0	fil.	fil.	-1.5	-42	-1.5	---	---
V501	-37	-50	-51	fil.	fil.	-1.5	-63	-51	n. c.
V802	170	-37	-31	fil.	fil.	270	44	60	n. c.
V505	170	-92	-50	fil.	fil.	170	-108	-92	n. c.
V502	-2.4	-1.5	fil.	fil.	-1.3	n. c.	-1.5	---	---
V503	270	-2.4	6.8	fil.	fil.	270	-11	-2.4	n. c.
V504	0	-2.3	0	fil.	fil.	fil.	53	108	0
V901	170	-31	-7.7	fil.	fil.	170	-5.6	-1	n. c.
V902	68	-8	-7.1	fil.	fil.	270	68	72	n. c.
V801	140	-18	0	fil.	fil.	150	-20	0	n. c.

Dual Trace Blanking Board A-106865

Measure between Tube Pin and Ground	1	2	3	4	5	6	7	8	9
V1301	7	5	170	fil	fil	2	0	100	62

Low Voltage Regulator Board A-106791

Measure between Tube Pin and Ground	1	2	3	4	5	6	7	8	9
V601	270	271	fil.	fil.	460	300	270	---	---
V602	169	170	fil.	fil.	290	205	170	---	---
V603	170	171	fil.	fil.	260	200	171	---	---
V604	-.7	0	fil.	fil.	130	24	0	---	---
V605	-74	-72	fil.	fil.	-25	0	-72	---	---
V606	460	660	480	460	660	480	fil.	fil.	---
V607	300	483	360	300	483	360	fil.	fil.	---
V608	260	400	270	260	400	270	fil.	fil.	---
V609	130	260	170	130	260	170	fil.	fil.	---
V610	-25	84	0	-25	84	0	fil.	fil.	---
V611	-62	-150	n. c.	-150	-62	n. c.	-150	---	---
V612	.9	-62	-61	fil.	fil.	0	-60	-61	fil.
V613	170	105	93	fil.	fil.	170	0	-44	93

High Voltage Power Supply Circuit Board A-106776

Measure between Tube Pin and Ground	1	2	3	4	5	6	7	8	9
V701	-40	0	fil.	fil.	400	105	-40	---	---
V702	105	-4.4	0	fil.	fil.	-4.4	-160	-150	fil.

SECTION VI CALIBRATION AND ADJUSTMENT

6-1. Calibration and Adjustment. A complete recalibration of the MEMO-SCOPE Oscilloscope, Model 105A, should not be necessary unless the output levels of the high or low voltage power supplies have been changed, or unless the MEMOTRON tube has been replaced.

If extensive repairs have been made, it is strongly recommended that the MEMOTRON tube be removed (see Section 5-3-5) and a preliminary check made of the voltage levels at the various MEMOTRON tube pin connections, particularly the front end connectors. Gross variations from proper voltage levels must be corrected before the MEMOTRON tube is reconnected.

Individual circuits may be recalibrated separately if the high and low voltage power supply outputs do not require adjustment.

When a complete recalibration of the instrument is required, it should be performed in the following sequence:

Recalibration Sequence

1. Low Voltage Power Supply
2. Vertical and Horizontal Amplifier d-c Balance Adjustment.
3. High Voltage Power Supply
4. Sweep Circuit Adjustments.
 - a. Reset Circuit
 - b. 2nd Schmitt Trigger
 - c. 1st Schmitt Trigger
 - d. Calibrator
5. Horizontal Amplifier.
 - a. TIME/DIV Switch Calibration
 - b. MULTIPLIER Switch Calibration
 - c. MAGNIFIER Switch Calibration
6. Vertical Amplifier.
7. Preamplifier.
8. Storage Circuits.
 - a. Ion Repeller.
 - b. Collimation.
 - c. Speed Enhancement.
 - d. Contrast Enhancement.

6-2. Calibration Equipment. To perform a complete recalibration of the instrument, the following equipment will be required:

Oscilloscope, calibrated; of at least 15 megacycle response.

Sine Wave Oscillator, with frequency range of 100 c.p.s. to 10 megacycles; capable of 10 volts p/p signal output.

Square Wave Generator, with frequency range of 1 KC to 100 KC; rise time must be less than 20 nanoseconds.

a-c/d-c Voltmeter, 20,000 ohms per volt; or VTVM.

Preamplifier, Extension Plug, Hughes Part No. A-106430.

6-3. Preconditions. Before recalibrating the instrument, be certain that the instrument is functioning properly. All circuits should be in a normal operating condition, since operation of certain circuits depends upon proper operation of other circuitry.

Turn power on.

Turn INTENSITY control fully counter-clockwise, or defocus the spot.

Turn STABILITY control fully counter-clockwise, ~~stopping~~ the sweep.

Turn STORAGE switch to OFF.

Allow 10 minutes for warm-up.

6-4. Low Voltage Power Supply. When making adjustments on this or any other circuit, normal safety precautions should be observed. Output of the Low Voltage Power Supply is easily measured at the terminal board located at the top rear of the oscilloscope. Measurements made with a d-c voltmeter between terminal and chassis should agree with the voltage levels indicated on the terminal board.

Set the level of the -150 volt reference voltage by adjusting R647 (screwdriver adj.) located at the rear of the Low Voltage Regulator Board (Printed Circuit Board A-106791.)

Set the level of the + 500 supply at approx. + 500v by adjusting R627.

Set the level of the + 360 volt supply at approx. + 360v by adjusting R637.

Fig. 16

6-5. Horizontal and Vertical Deflection Plate Levels. Set the CRT spot (with sweep inoperative) as close to the center of the screen as possible. Connect a d-c voltmeter between the terminal leads of R325 and R324, located on the Horizontal Amplifier Circuit Board. Adjust the HORIZ POSITION control until a reading of zero volts is observed on the meter. Reconnect the meter between R325 and the +270 volt terminal. Adjust R627 (+500 V Adj.) until a reading of zero volts is observed on the meter. TOP

Repeat the above procedure for setting the voltage level at the vertical deflection plates, DV1 and DV2. Connect the voltmeter between the terminal leads of R251 and R250 on the Vertical Amplifier Circuit Board. Adjust the VERT POSITION control until a reading of zero volts is observed on the meter. Reconnect the meter between R251 and the +270 volt terminal. Adjust R637 (+360 V adj.) until a reading of zero volts is observed on the meter. Fig 11A

6-6. High Voltage Power Supply.

CAUTION

OBSERVE ALL NORMAL SAFETY PRECAUTIONS WHEN SERVICING THE HIGH VOLTAGE POWER SUPPLY. USE A WELL INSULATED SCREWDRIVER WHEN MAKING ANY ADJUSTMENTS.

Using a d-c voltmeter, measure -1450 volts between pin jack J706 and chassis. This voltage is set by potentiometer R707, located in the high voltage power supply box. A well insulated screwdriver must be used when adjusting R707.

R715 provides a grid bias adjustment to prevent the CRT grid from being driven beyond safe limits in a positive direction.

With the INTENSITY control set at maximum (fully clockwise), R715 is set to allow sufficient bias (about 15-30 volts) to prevent damage to the MEMOTRON tube in the event of component failure. This adjustment is factory set for each individual MEMOTRON tube, and should not be reset unless the storage tube has been replaced. Since, in effect, the exact setting of R715 is a compromise between maximum available writing speed and burn-out protection, this adjustment should only be attempted by thoroughly experienced personnel. DON'T DO IT!

The adjustment should be made with the INTENSITY control at a low setting, and the beam slightly out of focus. Set the TIME/DIV switch at 10 MILLISEC per division. Adjust R715 for a bias of 25 volts with the sweep stopped. This measurement is made with a high impedance voltmeter between pins 4 and 9 of T701. Remove the voltmeter from the circuit.

A very small current is conducted through Diode D705 during back-biased conditions, creating a loading effect which affects the intensity pulse. As R715 is adjusted toward greater protective voltage, this loading is increased. Thus, the adjustment is one which gives the proper protective voltage without affecting the Z-Axis pulse.

Start the sweep and check the trace for any tendency toward non-uniformity in brightness as it crosses the screen. If the trace is not of uniform brightness, slowly decrease the bias by adjusting R715 while observing the trace for constant intensity of brightness. As the point where uniform brightness is approached, decrease the intensity with the front panel control to a very dim brightness and focus the beam. This will aid in observing any non-uniformity of brightness. The optimum setting of R715 will be that point where the trace just begins to be uniform in brightness at all points as it sweeps across the screen.

6-7. Sweep Circuit Adjustments.

Turn R525 (Swp. Lgth.) for maximum sweep length (fully counter-clockwise).

Adjust R509 (Trig. Bias) until the sweep generator is free running when the STABILITY control is set at mechanical center and will not free run when the STABILITY control is set to the left of mechanical center.

Set the SYNC LEVEL control to mechanical center and the SYNC MODE control for a-c operation.

Set the R417 (Trigger Sensitivity Adjust) to its approximate mechanical center.

Turn the SYNC SLOPE switch to INT+ .

Inject a 10KC sine wave signal of approximately 5 volts peak-to-peak into the preamplifier input jack. Set the preamplifier controls for a full scale deflection.

Set the preamplifier INPUT switch at ground.

Turn the STABILITY control counter-clockwise until the sweep stops, then continue beyond this point for about 20 degrees.

Readjust preamplifier controls for presentation of the sine wave.

Adjust R420 (Trig Level Adj) until the 1st Schmitt Trigger, V402, is triggered by the 5 volt, 10KC signal. This will now be observable on the viewing screen as a synchronized sine wave.

Reduce the amplitude of the signal voltage and adjust the SYNC LEVEL control to the most sensitive point where triggering is possible on a 1 division peak-to-peak signal.

Turn the SYNC SLOPE switch to INT-. Check whether the 1st Schmitt Trigger will fire with the SYNC SLOPE switch in this position. If not, reset the SYNC LEVEL control to a point where it will fire. Now set the SYNC LEVEL control to a point midway between the two settings where V402 was found to trigger.

It will be necessary to adjust the SYNC LEVEL control and R420 simultaneously until the point is found where V402 will fire with the SYNC SLOPE switch in the INT+ and INT- positions without changing the setting of the SYNC LEVEL control.

Without changing the potentiometer setting, loosen the black knob on the SYNC LEVEL control and reset the knob so that the white line is in a vertical (centered) position.

Disconnect the sine wave generator and check the 1st Schmitt Trigger for oscillation. Oscillation will be observed as a non-triggered sweep, and can be checked by setting the preamplifier INPUT selector switch to ground with the SYNC LEVEL and STABILITY controls set at their most sensitive triggering positions.

If the 1st Schmitt Trigger is oscillating, adjust R417 a little beyond the point where oscillation stops, i.e., the sweep stops.

If the 1st Schmitt Trigger did not oscillate after disconnecting the sine wave generator, adjust R417 until oscillation begins, then follow the procedure given in the preceding paragraphs.

6-8. Calibrator Adjustment.

Set the CALIBRATOR switch in the 100 volt position.

Using a test oscilloscope, adjust R809 (Calib.) until a 1 KC square wave with an amplitude of 100 volts is measurable between the Calibrator Output Jack and ground.

6-9. Horizontal Deflection System.

Connect a marker generator to the preamplifier input.

Set the SYNC MODE switch at a-c.

Set the SYNC SLOPE switch at INT+.

Set the TIME/DIV switch at 10 milliseconds per division.

Set the MAGNIFIER at 1X.

Set the MULTIPLIER at 1.

Set the VARIABLE control at CAL.

Inject a 10 millisecond marker signal.

Adjust R302 (Sweep Gain) until 11 marker pulses are in line with the 11 vertical lines on the graticule.

Adjust R525 (Swp., Lgth.) until the sweep length measures 10 1/2 divisions on the graticule.

Set the TIME/DIV switch at 1 microsecond per division.

Inject a 1 microsecond signal. *marker*

Adjust C512 (located on the TIME/DIV switch) until 11 marker pulses are in line with the 11 vertical lines on the graticule.

Set the TIME/DIV switch at .1 microsecond per division.

Inject 10 MC signal

Using a test oscilloscope, observe the sawtooth wave form at pin 3 of V301A. Adjust C301 for optimum linearity of the sawtooth.

Adjust C514 until 11 ^{*sine waves*} ~~marker pulses~~ are in line with the 11 vertical lines on the graticule.

A slight distortion of the marker pulses may be observed over the first graticule division. If distortion is observed, adjust C305 for optimum linearity at the beginning of the sweep. If the range of C305 is insufficient due to improper tube matching in the Horizontal Amplifier, it may be necessary to pad the trimmer with a fixed mica capacitor. A slight readjustment of C301 may improve the overall linearity. Since an interrelationship exists between the two adjustments, it may be found necessary to repeat the adjustment of C305 and C301.

6-10. Multiplier Calibration.

Connect a marker generator to the preamplifier input. Set generator output for 100 millisecond markers.

Set the TIME/DIV switch at 10 milliseconds per division.

Set the MAGNIFIER switch at 1 X.

Set the MULTIPLIER switch at 2X.

Set the VARIABLE control at CAL.

Observe 3 markers on the viewing screen. Adjust R552 (Mult) until the first and last markers are in line with the first and last vertical lines of the graticule.

Set the MULTIPLIER switch at 9. Adjust R634 (Mult Aux) located on the Storage Board until the first marker is in line with the first vertical line of the graticule, and the 10th marker is in line with the 11th vertical line.

It may be necessary to repeat adjustment of R634 and R552 due to interaction of the circuitry.

6-11. Magnifier Calibration.

Connect a marker generator to the preamplifier input. Set generator output for 10 millisecond markers.

Set the TIME/DIV switch at 10 milliseconds per division.

Set the MULTIPLIER switch at 1.

Set the MAGNIFIER switch at 5X.

Adjust R321 (Mag Gain) until the first marker is in line with the first vertical line of the graticule, the second marker is in line with the sixth (center) line, and the third marker is in line with the 11th vertical line.

Switch the MAGNIFIER to 1X.

Adjust the HORIZ POSITION control until the first marker is in line with the sixth (center) vertical line of the graticule.

Switch the MAGNIFIER to 5X.

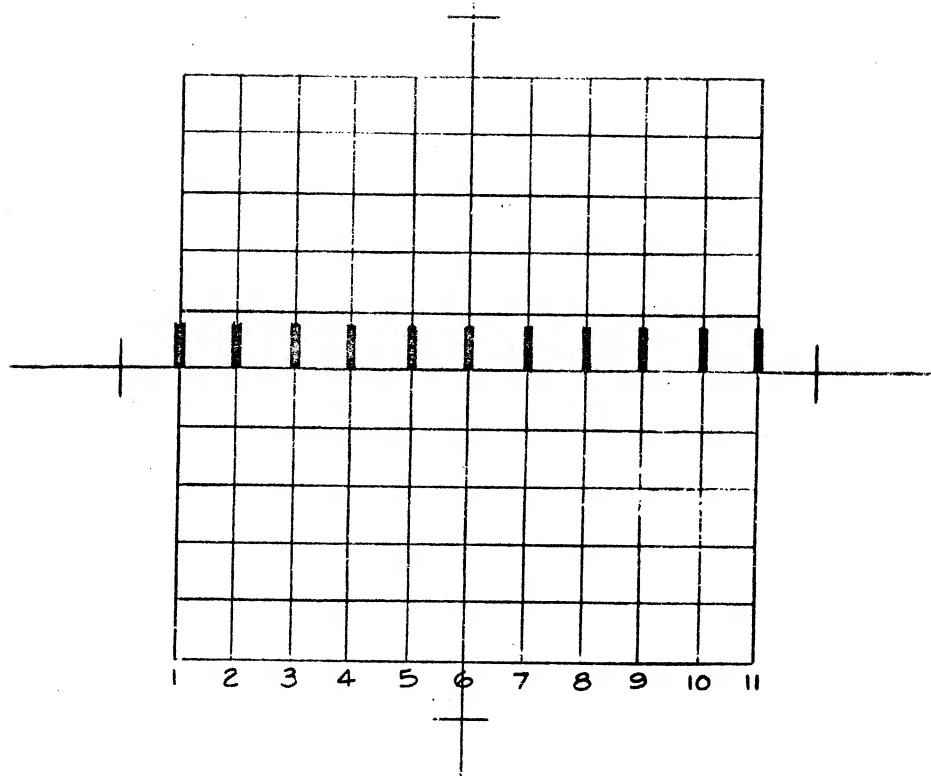
Adjust R309 (Mag Pos) until the first marker is in line with the sixth (center) line of the graticule.

Switch the MAGNIFIER to 1X.

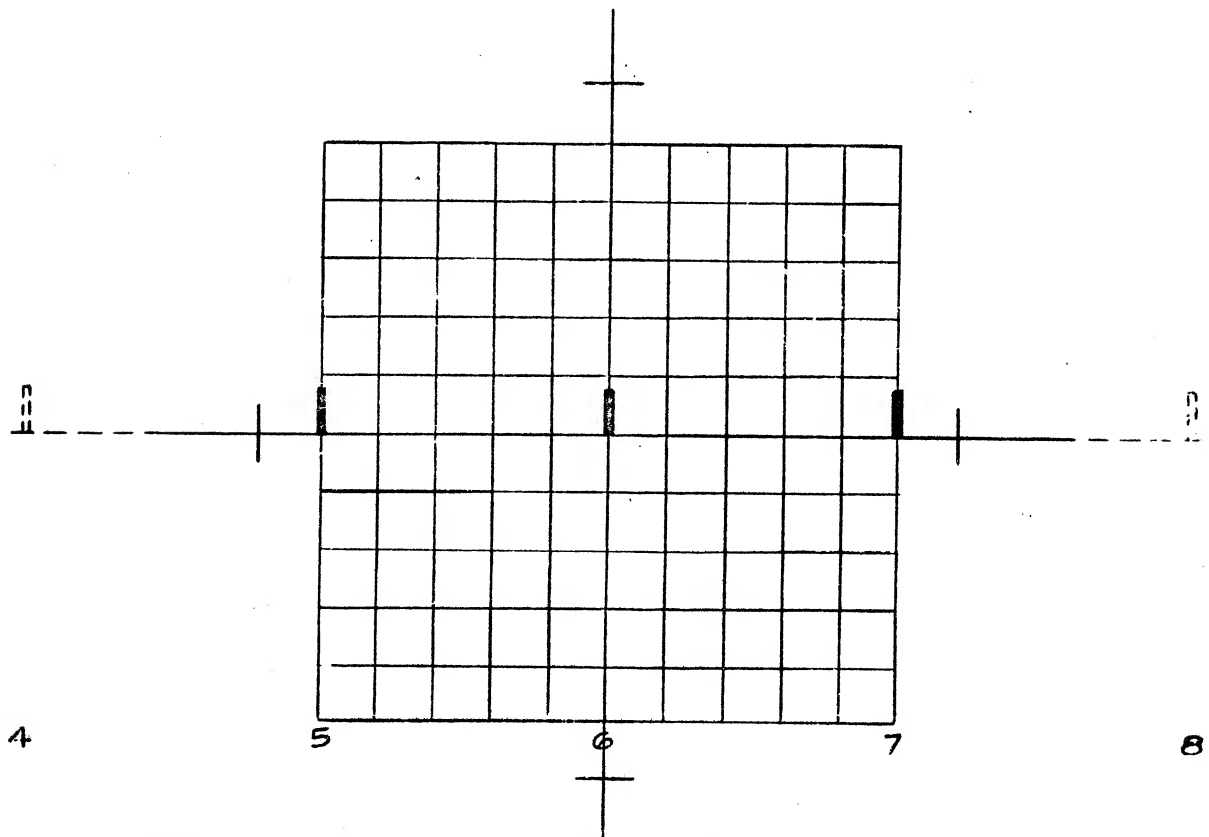
Adjust the HORIZ POSITION control until the first marker is in line with the first vertical line of the graticule and the sixth marker is in line with the center line.

Switch the MAGNIFIER to 5X. Note that the sixth marker* is approximately in line with the vertical center line. Adjust R309 until the sixth marker is properly aligned with the center line. The sixth marker should remain aligned with the graticule center line when the MAGNIFIER is in either the 1X or 5X position.

*Note: Expansion of the trace due to change of MAGNIFIER setting is from the center toward both ends, as illustrated below:



10 Millisecond Markers with Magnifier at 1X



10 Millisecond Markers with Magnifier at 5X

k) Set the TIME/DIV switch to .1 microsecond per division.

l) Set the MAGNIFIER switch to 5 X.

m) Examine the trace for overall linearity and adjust C304 for optimum results. It may prove necessary to replace padding capacitor C307 to one of another value.

n) Switch the MAGNIFIER to 1 X and re-examine the overall linearity. A final very fine tuning of C301 and C305 may improve linearity.

IX 6-12. Vertical Amplifier Calibration. Due to the interdependence of the Vertical Amplifier Circuit and the Preamplifier, the oscilloscope undergoing recalibration should be used in conjunction with a Model 05-1 Wideband Preamplifier, properly adjusted for gain, d-c balance and high frequency response.

a) Set Model 105A controls as follows:

~~Turn power on and allow at least 15 minutes for warm-up.~~

~~Set the TIME/DIV switch at 1 millisecond per division.~~

~~Set the MAGNIFIER switch at 1 X.~~

~~Set the MULTIPLIER switch at 1.~~

~~Set the STABILITY control fully clockwise. The sweep should now free run.~~

b) Connect a jumper across pins 14 and 16 of preamplifier plug P201.

c) Adjust R212 (Vert. Amp. Bal.) until trace is centered.

d) Remove jumper from pins 14 and 16.

e) Connect ^{check 11 P212A} a voltmeter between the vertical deflection plates D1 and D2 of the MEMOTRON tube. (wires # 4+5)

f) Adjust
Adjust the preamplifier VERT POSITION control until a reading of zero volts is observed on the meter.

g) Connect a jumper across D1 and D2.

h) Measure the voltage between either D1 and D2 and ground. If a reading of 270 volts is not observed, adjust R637 on the Low Voltage Regulator Board for the proper level.

(g) through (d)
i) Repeat the first 3 steps above to insure proper amplifier balance.

- j) Remove jumper ^{from D1 and D2.} from D1 and D2.
- k) ~~Reinsert preamplifier into oscilloscope and connect~~ ^{Connect} a lead between the Calibrator output jack and the preamplifier input jack.
- l) Using ^{the Type 545A with Type D Plug In, set for differential input,} a test oscilloscope ^{Control} provided with a differential preamplifier, measure the signal between the grids of V201 and V202 ~~(pin 1 and pin 1)~~ in the Vertical Amplifier. Adjust the calibrator and preamplifier gain controls to provide a 1.6 volt peak-to-peak signal at this point.
- m) Adjust R205 (Gain) for 10 divisions of vertical deflection.
- n) Connect a properly terminated ^{Type 105} square wave generator having a rise time of at least 20 millimicroseconds to preamplifier INPUT A. Set the ^{Type 105} generator for 100 KC square wave output.
- o) Temporarily adjust peaking coils L201 and L202 for minimum inductance. Adjust L210 and L211 for the best corner on the leading edge of the square wave displayed on the viewing screen.
- p) Adjust C206 for minimum droop. It may be necessary at this point to readjust L210 and L211.
- q) Re-adjust L201 and L202 until overshoot just appears on the square wave, and for the best rise time.
- r) Disconnect the square wave generator.

X 6-12-1. D.C. Shift Compensation. To compensate for d-c shift when measuring signals of very low frequencies, i.e. d-c to a fraction of a cycle, proceed as follows:

- b) Set oscilloscope trigger controls for free running operation and storage controls for storage operation.
- c) ^{model 105A} Set TIME/DIV switch at 100 Millisec.
 Set MULTIPLIER at 5.
 Set MAGNIFIER at X1.
^{model 95-1} Set preamplifier VOLTS/DIV switch at .1
 Set preamplifier Variable VOLTS/DIV control at CAL
 Set INPUT at D.C.
- d) Make a momentary contact with a 1.5 volt ^{battery} dry cell to the preamplifier input and observe the trace. The writing beam should describe a square wave with no overshoot or undershoot. If overshoot or undershoot with a duration of 2 or 3 seconds is observed, adjust R258 (D.C. Shift Comp) located on the Dual Trace Blanking Board until the beam describes a square wave with a flat top when momentary contact is made with the ~~dry cell~~ ^{battery}.

XI ~~6-13.~~ Storage Circuit Calibration. ^{b)} Set the oscilloscope controls for a trace which is of low intensity and out of focus.

~~6-13-1.~~ Ion Repeller Potential. ^{b)} To set the proper voltage level on the Ion Repeller, adjust R125 (located on the Storage Control Chassis) until ^{there is} 420 volts ^{measured with the H-P 412A} is measurable between the center tap of R125 and ground.

~~6-13-2.~~ Collimation Level.

c) Set the STORAGE switch at STORE.

d) Turn the THRESHOLD control to the point required for adequate storage, but no farther.

e) Allow the sweep trace to fill the screen fully with stored traces, using a defocused beam of low intensity.

f) Adjust R108 (located on Storage Control Chassis) until the patterns of the two flood guns are collimated and fully cover the screen with uniform patterns.

~~6-13-3.~~ Speed Enhancement Level.

NOTE: ^{The speed enhancement is} This circuit has been ~~factory~~ set for maximum writing speed with a minimum of background brightness. Use extreme care in making this adjustment to avoid a decrease in writing speed. For instructions in measuring writing speed, see ~~6-13-4.~~ ^{Section XII.}

g) ^{Set Model 1054 controls as follows:}

~~Set the~~ TIME/DIV switch at 1 millisecond per division.

~~Set the~~ SYNC MODE switch at a-c.

~~Set the~~ SYNC SLOPE switch at INT+.

~~Set the~~ MULTIPLIER at 1.

~~Set the~~ ^{SWEEP} sweep switch at NORMAL.

~~Set the~~ STORAGE switch at FAST.

~~Set the~~ THRESHOLD control fully counter-clockwise.

h) Set the SYNC LEVEL and STABILITY controls for free running sweep.

Tappe 545A,
i) Using the ~~test oscilloscope~~, observe the waveform at the junction of D102 and the center tap of R105. The waveform should be a negative pulse of approximately 60 volts amplitude and 400-800 microseconds duration. ~~For pulse shape, see Dwg. 106901.~~

j) Adjust R102 until the pulse width is approximately ^{600 μ sec ?} 60 volts peak.

k) Inject a 100KC sinewave ^{from the H-P 650A} signal into preamplifier INPUT A.

l) Adjust the preamplifier GAIN control until an excursion of 10.6 divisions is observed on the viewing screen.

m) *Set Model 105A controls as follows;*

Set the TIME/DIV switch at 10 microseconds per division.

~~Set the SYNC SLOPE switch at EXT+ and SYNC MODE at a-c.~~
SYNC MODE AC

Set the SWEEP switch at SINGLE.

n) Adjust the SYNC LEVEL and STABILITY controls so the oscilloscope does not retrigger when the SWEEP switch is reset. Test this setting several times with the RESET position of the SWEEP switch.

o) Set the CALIBRATOR for 10 volts output.

p) Connect a lead from the calibrator output jack. Make a momentary contact by brushing the end of the lead to the EXT TRIG input jack.

q) Readjust the SYNC LEVEL and STABILITY controls until a single trace sweeps across the screen each time the SWEEP switch is reset and momentary contact is made between the lead and the EXT TRIG input jack.

note
~~NOTE:~~ After each single sweep, be sure to depress the ERASE button to prevent "blooming" or build-up of background brightness.

r) Set the THRESHOLD control just beyond the point required for adequate storage.

s) Fire several single sweeps with the lead from the calibrator output as described above. Be sure to depress the ERASE button after each single sweep.

t) Turn the INTENSITY control clockwise to the point where blanking is overridden.

U) Reduce the intensity to the point where blanking just becomes effective.

V) Again fire several single traces. Insure that the ASTIGMATISM and FOCUS controls are set for optimum performance.

W) Readjust R105 until a well-defined trace is stored without flooding of background. If the background floods while making this adjustment, wait for a few minutes after erasure to allow full discharge of the storage meshes. Since the setting of R105 affects the writing speed, care should be exercised in making this adjustment.

XII 6-13-4. Measurement of Writing Speed.

from the H-PC50A
a) Inject a sine wave signal into the preamplifier input.

b) Adjust the amplitude of the waveform for a 10.6 divisions (3.18 inches) peak-to-peak.

c) Adjust the sweep speed so several cycles (at least 5) appear across the viewing screen.

d) When the above conditions are met, the maximum velocity of the writing beam in inches per second is 10 times the frequency of the sinewave signal in cycles per second.

e) When measuring the writing speed of the oscilloscope, use the single sweep mode to prevent integration of the traces. Over the center 3/4 inches of the graticule, writing beam velocity is almost constant ($\pm 2.5\%$). Writing speed is thus defined as the speed during the interval when the beam is passing through the center 3/4 inch area and effecting storage in the single sweep mode, with 75% of the 3/4 inch band being stored.

XIII 6-13-15. Contrast Enhancement Adjustment.

Type 545A with Type K Plug-In
a) Using the test oscilloscope, observe the waveform at the junction of D106, R128, and C108. This should appear as a pulse of approximately 10 microseconds width and 10-30 volts in amplitude.

b) Adjust R118 (located on the Storage Board.) for desired brightness of background.

SECTION VII PARTS LIST

7-1. Ordering Procedure. The majority of parts required for replacement are available at most electronic supply houses. The parts lists include the manufacturer's name and part number for those components which require exact electrical or mechanical matching. Components and assemblies which have been designed exclusively for use in the MEMO-SCOPE Oscilloscope, Model 105A are marked with an asterisk in the parts lists, and can be ordered from:

Hughes Aircraft Company
Vacuum Tube Products Division
Marketing Department
2020 Short Street
Oceanside, California

Be sure to include the Hughes (HAC) number and the method of transportation desired when ordering replacement parts. The (A) numbers on the right hand column indicate the printed circuit board on which the part is mounted. When ordering a printed circuit board without components, use the board number. When a complete assembly is desired, use the assembly number. Both numbers can be found beneath the applicable photograph in Section VII of this manual.

7-2. Storage Controls. Dwg. A-106901.

Resistors

<u>Component No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
R101	100K 5% 1/2 Watt		A-106864
*R102	1 Meg Pot .2 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8" ("L")	"
R103	200K 5% 1/2 Watt		"
R104	200K 5% 1/2 Watt		"
*R105	10K Pot .3 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8" ("L")	"
R106	300K 5% 1/2 Watt		"
R107	10K 5% 1/2 Watt		"
*R108	25K Pot .2 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8" ("L")	"
R109	75K 5% 1/2 Watt		"
R110	68K 5% 2 Watt		S101-B
*R111	100K Pot 1 Watt	CTS Type 90CV bushing length 3/16" shaft length 3/8" (L) slot of shaft 3/64" wide 1/8" deep	S101
R112	24K 5% 1/2 Watt		S101-B-C

<u>Component No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
R113	1K 5% 1/2 Watt		A-106864
R114	430K 5% 1/2 Watt		"
R115	100K 5% 1/2 Watt		R-116
*R116	500K Pot .25 Watt	CTS Type 45 bushing length 3/8" shaft length 3/4" (L)	Front Panel
R117	1.1 Meg 5% 1/2 Watt		A-106864
*R118	500K Pot .2 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8" ("L")	"
R119	510 ohms 5% 1/2 Watt		S-101-A-B
R120	47K 5% 1 Watt		A-106864
R121	120K 5% 1/2 Watt		S-101-A-B
R122	33K 5% 1/2 Watt		S101-A
R123	68K 5% 1/2 Watt		S102-J101
R124	2.2K 5% 1/2 Watt		A-106864
*R125	100K Pot .2 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8" ("L")	"
R126	68K 5% 1/2 Watt		"
R127	270 ohms 5% 1/2 Watt		A-101-A-B
R128	2.2K 5% 1/2 Watt		A-106864

Capacitors

C101	47mmfd 5% 500V	Silver-Mica	A-106864
C102	150 mmfd 5% 500V	Silver-Mica	"
C103	.01 mfd 20% 200V	Difilm	"
C104	100 mmfd 5% 500V	Silver-Mica	"
C105	.22 mfd 20% 400V	Paper, Tubular	"
C106	.047 mfd 20% 400V	Paper, Tubular	"
*C107	2 mfd 20% 300V	Jedco # 118	"
C108	.0022 mfd 20% 600V	Difilm	"

Diodes

D101	Silicon Rectifier	DI 56	A-106864
D102	Silicon Rectifier	DI 56	"
D103	Silicon Rectifier	DI 56	"
D104	Silicon Rectifier	DI 56	"
D105	Silicon Rectifier	DI 56	S102
D106	Silicon Rectifier	DI 56	A-106864

Tubes

V101	12AU7		A-106864
V102	6DJ8		"
*V103	MEMOTRON (R) Tube	HAC Type H-1051	

<u>Component No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
*S101	Switch Assembly	HAC A-106624	
S102	Pushbutton	Grayhill # 2201	

7-3. Vertical Amplifier. Dwg. A-106902

R201	10 ohms 5% 1/2 Watt		A-106790
R202	750 ohms 5% 1/2 Watt		"
R203	1.69K 1% 1/2 Watt		"
R204	1.69K 1% 1/2 Watt		"
*R205	500 ohms Pot .3 Watt CTS Type U70 bushing length 1/4", shaft-		"
R206	4.7K 5% 2 Watt		length 3/8"
R207	4.7K 5% 2 Watt		"
R208	470 ohms 5% 1/2 Watt		"
R209	240 ohms 5% 1/2 Watt		"
R210	470 ohms 5% 1/2 Watt		"
R211	56K 5% 1/2 Watt		"
*R212	100K Pot .2 Watt CTS Type U70 bushing lgth.1/4" shaft lgth.3/8		"
R213	56K 5% 1/2 Watt		"
*R214	See L-203 listed under coils 2.2K 1%		"
*R215	See L-204 listed under coils 2.2K 1%		"
R216	56 ohms 5% 1/2 Watt		"
R217	470K 5% 1/2 Watt		"
R218	18K 5% 2 Watt		"
R219	56 ohms 5% 1/2 Watt		"
R220	10 ohms 5% 1/2 Watt		"
*R221	See L-205 listed under coils 3.3K		"
*R222	See L-208 listed under coils 4.7K		"
*R223	See L-209 listed under coils 4.7K		"
*R224	See L-206 listed under coils 3.3K		"
R225	10 ohms 5% 1/2 Watt		"
R226	4.7K 5% 1 Watt		"
R227	1K 5% 1/2 Watt		"
R228	2.2K 1% 1/2 Watt		"
R229	2.2K 1% 1/2 Watt		"
R230	3.6K 5% 1/2 Watt		"
R231	3.3K 5% 1/2 Watt		"
R232	3.3K 5% 1/2 Watt		"
R233	100 ohms 5% 1/2 Watt		"
R234	10 ohms 5% 1/2 Watt		"
R235	330 ohms 5% 1/2 Watt		"
R236	12K 5% 2 Watt		"
R237	12K 5% 2 Watt		"
*R238	3K 5% 10 Watt	Lectrohm Inc. Non-Inductive P.C.B. Type	"
*R239	4K 5% 10Watt	Lectrohm Inc. Non-Inductive P.C.B. Type	"
*R240	4K 5% 10 Watt	Lectrohm Inc. Non-Inductive P.C.B. Type	"

<u>Component No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
*R241	3K 5% 10 Watt	Lectrohm Inc., Non-Inductive PCB Type A-106790	"
R242	3.3K 5% 1/2 Watt	"	"
R243	3.3K 5% 1/2 Watt	"	"
R244	270K 5% 1/2 Watt	"	S401-C-D
R245	150K 5% 1/2 Watt	"	"
*R246	100K Pot .2 Watt	CTS Type U70 bshg.lgth.1/4", shaft length 3/8"	Upper right frame member A-106790
R247	5.6K 5% 2 Watt	"	"
*R248	See L-212 listed under coils 4.7K	"	"
*R249	See L-213 listed under coils 4.7K	"	"
R250	100K 5% 1/2 Watt	"	"
R251	100K 5% 1/2 Watt	"	"
R252	33K 5% 1/2 Watt	"	"
R253	510K 5% 1/2 Watt	"	"
R254	18K 5% 2 Watt	"	"
R255	10 ohms 5% 1/2 Watt	"	"
R256	3K 5% 5 Watt	"	"
R257	68K 5% 1/2 Watt	"	A-106865
R258	1 meg. Pot	"	A-106790
R259	68K 5% 1/2 Watt	"	"
R260	470K 5% 1/2 Watt	"	"
R261	2.2K 5% 1/2 Watt	"	"
R262	2.2K 5% 1/2 Watt	"	"
R263	3.6K 5% 1/2 Watt	"	"

Capacitors

C201	.01 mfd 10% 400V	Mylar	A-106790
C202	330 mmfd 5% 500V	Silver-Mica	"
*C203	20/20.50. mfd 5% 200V	Electrolytic Gen. Inst. Co. Type ATM 1 1/2 diameter	"
C204	.01 mfd 10% 400V	Mylar	"
C205	.01 mfd 20% 600V	Ceramic Disk	"
C206	7-45 mmfd Variable	Ceramic	"
C207	.015 mfd 10% 400V	Mylar	"
C208	100 mmfd 5% 500V	Silver-Mica	"
C209	6.8 mmf 5% 500V	Silver-Mica El Menco Arco	S401-C-D
C210	47 mmfd 5% 500V	Silver-Mica	A-106790
C211	.1 mfd 20% 300V	Ceramic Disk	Front Panel V.Pos. Lamp
C212	8/8 mfd. 20% 450V	Electrolytic	A-106865
C213	.1 mfd. 20% 500V	Ceramic Disk	"
C214	.005 mfd 20% 500V	Ceramic Disk	A-106790
C215	.005 mfd 20% 500V	Ceramic Disk	"
C216	not used		
C217	.02 mfd. 20% 500V	Ceramic Disk	"
C218	.01 mfd 10% 400V	Mylar	"

<u>Component No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
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Tubes

V201	6DK6		A-106790
V202	6DK6		"
V203	6BQ7		"
V204	6BQ7		"
V205	12BY7		"
V206	12BY7		"
V207	6AW8		"
V208	6AW8		"

Coils

L201	2-3.7microhenry	CTC X2060-1	A-106790
L202	2-3.7microhenry	CTC X2060-1	"
*L203	Special Coil (Incl. R214)	HAC A-106630	"
*L204	Special Coil (Incl. R215)	HAC A-106630	"
*L205	Special Coil (Incl. R221)	14 microhenry	"
*L206	Special Coil (Incl. R224)	14 microhenry	"
L207	33 microhenry	Cambridge Thermionic Corp. # 2082-5	"
*L208	Special Coil (Incl. R222)	14 microhenry	"
		Cambridge Thermionic Corp. # 2082-5	"
*L209	Special Coil (Incl. R223)	14 microhenry	"
		Cambridge Thermionic Corp. # 2082-5	"
L210	16-28 10-18 microhenry	Cambridge Thermionic Corp. # X2060-4	"
L211	16-28 10-18 microhenry	Cambridge Thermionic Corp. # X2060-4	"
*L212	Special Coil (Incl. R248)	7.5 microhenry	"
		Cambridge Thermionic Corp.	"
*L213	Special Coil (Incl. R249)	7.5 microhenry	"
		Cambridge Thermionic Corp.	"
L214	14 microhenry		"
L215	14 microhenry		"
*Z201) 1/4 microsec. 2K (matched pair) Columbia Technical Co. Type HH2000		
*Z202			

Neon Lamps

I201	NE81	Front Panel
I202	NE81	Front Panel

7-4. Horizontal Amplifier Dwg. A-106903

Resistors

R301	47K 5% 1/2 Watt		A-106867
*R302	25K Pot .2 Watt	CTS Type U70 bushing length 1/4", slotted shaft length 3/8"	"
R303	27K 1% 1 Watt		A-106867

<u>Component No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
R304	39K 1% 1 Watt		A-106867
*R305)	100K/25K Dual Pot.	CTS Type 2-45 bushing length 3/8" outer shaft length 3/4" inner shaft length 1 1/4"	Front Panel
*R307)			"
R306	43K 1% 1 Watt		A-106867
R308	3.9K 5% 1/2 Watt		"
*R309	100K Pot. 2 Watt	CTS Type V95CV bushing length 3/8" shaft length 1/2"	"
R310	56 ohms 5% 1/2 Watt		A-106867
R311	56 ohms 5% 1/2 Watt		"
R312	47K 5% 1 Watt		"
R313	47K 5% 1 Watt		"
R314	56 ohms 5% 1/2 Watt		"
R315	56 ohms 5% 1/2 Watt		"
*R316	5K 5% 10 Watt	Lectrohm UC 10-5KT5	"
*R317	5K 5% 10 Watt	Lectrohm UC 10-5KT5	"
*R318	8K 5% 20 Watt	Lectrohm UC 20-8KT5	"
*R319	12K 5% 20 Watt	Lectrohm UC 20-12KT5	"
R320	2K 5% 1/2 Watt		A-106867
*R321	1K Pot. .3 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8"	"
R322	56 ohms 5% 1/2 Watt		A-106867
R323	56 ohms 5% 1/2 Watt		"
R324	82K 5% 2 Watt		"
R325	82K 5% 2 Watt		"
R326	82K 5% 2 Watt		"

Capacitors

C301	1.5-7mmfd Variable	Ceramic	A-106867
C302	27mmfd 5% 500V		"
C303	0.1 mfd 10% 100V		"
C304	7-45mmfd Variable	Ceramic	"
C305	7-45mmfd Variable	Ceramic	"
C306	560 mmfd 5% 500V	Silver-Mica	"
C307	82 mmfd 5% 500V	Silver-Mica	"

Tubes

V301	6DJ8		"
V302	12BY7		"
V303	12BY7		"
V304	12BH7		"

7-5. Trigger Amplifier. Dwg. A-106904

Resistors

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
R401	470K 5% 1/2 Watt		S401-C-D
R402	1 Meg 5% 1/2 Watt		S401-D
R403	56 ohms 5% 1/2 watt		A-106867
R404	2.7K 5% 1/2 Watt		"
R405	4.3K 5% 1/2 Watt		"
R406	56 Ohms 5% 1/2 Watt		"
R407	18K 5% 2 Watt		"
R408	1 Meg 5% 1/2 watt		S401-C
R409	330K 5% 1/2 Watt		S401-B-C
R410	39K 1% 1/2 Watt		S401-B-C
*R411	25K/100K Dual Pot.	CTS Type 2-45 bushing length 3/8" Front Panel outer shaft length 3/4", inner shaft length 1 1/4"	
R412	33K 1% 1/2 Watt		S401-B-C
R413	not used		
R414	2.2K 5% 1/2 Watt		A-106867
R415	180K 5% 1/2 Watt		"
R416	1K 5% 1/2 Watt		"
*R417	1K Pot. .3 Watt	CTS Type U70 bushing length 1/4" shaft length 3/8"	"
R418	15K 5% 2 Watt		A-106867
R419	470K 5% 1/2 Watt		"
*R420	100K Pot. .2 Watt	CTS Type U70 bushing length 1/4" shaft length 3/8"	"
R421	75K 5% 2 Watt		A-106867
R422	220K 5% 1/2 Watt		Reset Indicator Lamp
R423	2.2 Meg 5% 1/2 Watt		A-106867
R424	24K 5% 1/2 Watt		A-106867
R425	1.5 Meg 5% 1/2 Watt		"
R426	24K 5% 1 Watt		S403-A
R427	10 ohms 5% 1/2 Watt		S403-A
R428	20K 5% 1/2 Watt	Across R411 Front Panel	
R429	20K 5% 1/2 Watt	Across R411 Front Panel	
R430	3.3K 5% 1/2 Watt		A-106867

Capacitors

C401	.001 mfd 20% 600V	Paper, Tubular	S401-B-D
C402	.001 mfd 20% 600V	Paper, Tubular	S401-C-D
C403	27 mmfd 5% 500V	Silver-Mica	A-106867
C404	.001 mfd 20% 600V	Paper, Tubular	S401-C-D
C405	120 mmfd 5% 500V	Silver-Mica	A-106867
C406	.0047 mfd 10% 100V	Mylar	"
C407	27 mmfd 5% 500V	Silver-Mica	"
C408	47 mmfd 5% 500V	Silver-Mica	"
C409	.022 mfd 20% 200V	Paper, Tubular	S403-A

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
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Tubes

V401	6DJ8		A-106867
V402	6DJ8		"
V403	2D21		"

Diodes

D401 Silicon Diode	IN628		"
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Coils

L401	73 microhenry	Miller Company # 6172	"
L402	47 microhenry	Cambridge Thermionic Co. # X2082-6	"

Lamps

I401	Neon	Ne2a	Front Panel
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*S401 Sync. Slope Switch Assembly HAC A-106621

7-6. Sweep Generator. Dwg. A-106905

Resistors

R501	56 ohms 5% 1/2 Watt		A-106867
R502	1K 5% 1/2 Watt		"
R503	6.2K 5% 1/2 Watt		"
R504	15K 5% 2 Watt		"
R505	100 ohms 5% 1/2 Watt		"
R506	47K 5% 1 Watt		"
R507	62K 5% 1/2 Watt		"
R508	82K 5% 1/2 Watt		"
*R509	100K Pot. .2 Watt	CTS Type U70 bushing length 1/4", slotted shaft length 3/8"	
R510	100K 5% 1/2 Watt		A-106867
R511	820 ohms 5% 1/2 Watt		"
R512	240 ohms 5% 1/2 Watt		"
*R513	25K/100K Dual Pot.	CTS Type 2-45 bushing length 3/8", outer shaft length 3/4", inner shaft length 1 1/4"	Front Panel
R514	43K 5% 2 Watt		A-106867
R515	22K 5% 1 Watt		"
R516	4.7 Meg 5% 1/2 Watt		"
R517	240K 5% 1/2 Watt		S501-E-S301
R518	87K 1% 1/2 Watt		S501-C-S501-D
R519	987K 1% 1/2 Watt		S501-C-S501-D.

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
R520	10 Meg 1% 1/2 Watt		S501-C-S501-D
R521	82K 5% 1/2 Watt		1501
R522	100 ohms 5% 1/2 Watt		A-106867
R523	10K 5% 1/2 Watt		"
R524	30K 5% 2 Watt		"
*R525	2.5K Pot.	CTS Type U90CV bushing length 3/8" slotted shaft length 1/2" locking type bushing	"
R526	6.8K 5% 2 Watt		A-106867
R527	82K 5% 2 Watt		"
R528	56 ohms 5% 1/2 Watt		"
R529	100K 5% 1/2 Watt		"
R530	2.2 Meg 5% 1/2 Watt		"
R531	24K 5% 2 Watt		"
R532	24K 5% 2 Watt		"
R533	24K 5% 2 Watt		"
R534	30K 5% 2 Watt		"
R535	13K 1% 1/2 Watt		S502-A-B
R536	270 ohms 5% 1/2 Watt		S502-A-B
R537	4.7K 5% 1/2 Watt		S502-A-B
R538	6.8K 5% 1/2 Watt		"
R539	8.2K 5% 1/2 Watt		"
R540	9.1K 5% 1/2 Watt		"
R541	10K 5% 1/2 Watt		"
R542	24.9K 1% 1/2 Watt		"
R543	24.9K 1% 1/2 Watt		"
R544	24.9K 1% 1/2 Watt		"
R545	24.9K 1% 1/2 Watt		"
R546	24.9K 1% 1/2 Watt		"
R547	24.9K 1% 1/2 Watt		"
R548	24.9K 1% 1/2 Watt		"
R549	12.4K 1% 1/2 Watt		"
R550	12.4K 1% 1/2 Watt		S502-B-R551
*R551	15K Pot. S502, S503 Switch Assembly & 15K Pot. (Sweep Multiplier Switch Assembly)	HAC A-106622	S502-S503
*R552	250K Pot. .2Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8"	A-106867
R553	12.4K 1% 1/2 Watt		S502-B-R551
R554	16K 5% 2 Watt		S401-A-E
R555	56 ohms 5% 1/2 Watt		A-106867
R556	1K 5% 1/2 Watt		S-401A

Compo-
nents No.

Value

Mfg. Number

Location

Capacitors

C501	.01 mfd 10% 400V	Mylar	A-106867
C502	27 mmfd 5% 500V	Silver-Mica	"
C503	27 mmfd 5% 500V	Silver-Mica	"
C504	39 mmfd 5% 400V	Silver-Mica	"
C505	.25 mfd 20% 200V	Paper, Tubular	S501-B-S301
C506	.047 mfd 20% 200V	Paper, Tubular	S501-E-S301
C507	270 mmfd 5% 500V	Silver-Mica	"
C508	330 mmfd 5% 500V	Silver-Mica	"
C509	1 mfd 10% 300V)		S501-A-S301
C510	0.1 mfd 10% 300V)	matched	S501-A-B
C511	.001 mfd 10% 300V)		S501-A-B
C512	7-45 mmfd Variable		S501-A-B
C513	82 mmfd 5% 500V	Silver-Mica	"
C514	1.5-7 mmfd Variable		"
C515	.01 mfd 10% 400V	Mylar	A-106867
C516	220 mmfd 5% 500V	Silver-Mica	"
C517	470 mmfd 5% 500V	Silver-Mica	"

Tubes

V501	6DJ8		A-106867
V502	6AL5		"
V503	6DJ8		"
V504	12BY7		"
V505	6DJ8		"

Diodes

D501	Silicon	Diode Inc. DI 56	A-106867
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Coils

*L501	68 microhenry	CTC # X2082-7	A-106867
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*S501)			
*S502)	Time/Div. Switch Assembly	HAC A-106620	
*S503)			

Lamps

VR501	Neon	Ne2a	A-106867
VR502	Neon	Ne2a	"
I501	Neon	Ne2a	Front Panel

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
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7-7. Low Voltage Power Supply. Dwg. A-106906

Resistors

R601	4.7 ohm 5% 1 Watt		A-106863
R602	4.7 ohm 5% 1 Watt		"
R603	4.7 ohm 5% 1 Watt		"
R604	12 ohm 5% 2 Watt		"
R605	12 ohm 5% 2 Watt		"
R606	4.7 ohm 5% 1 Watt		"
R607	2.7 ohm 5% 1 Watt		"
R608	50 ohm Pot 10% 5 Watt	C.R.L. bushing length 3/8", shaft length 3/4"	
R609	150K 5% 2 Watt	- Front Panel	A-106791
R610	15K 5% 1/2 Watt		"
R611	150K 5% 1 Watt		"
R612	22K 5% 1/2 Watt		"
R613	220K 5% 1/2 Watt		"
R614	47K 5% 1/2 Watt		"
R615	220K 5% 1/2 Watt		"
R616	22K 5% 1/2 Watt		"
R617	15K 5% 1/2 Watt		"
R618	1 Meg 5% 1/2 Watt		"
R619	1 Meg 5% 1/2 Watt		"
R620	1 Meg 5% 1/2 Watt		"
R621	1 Meg 5% 1/2 Watt		"
R622	750K 5% 1/2 Watt		"
R623	15K 5% 1/2 Watt		"
R624	570K 1% 1/2 Watt		"
R625	200K 1% 1/2 Watt		"
R626	510K 5% 1/2 Watt		"
*R627	100K Pot .2 Watt	CTS U70 bushing length 1/4", slotted shaft length 3/8"	"
R628	1 Meg 5% 1/2 Watt		"
*R629	620K 1% 1/2 Watt		"
R630	500K 1% 1/2 Watt		"
R631	1 Meg 5% 1/2 Watt		"
R632	1 Meg 5% 1/2 Watt		"
R633	1.1K 5% 1/2 Watt		A-106863
*R634	500 ohm Pot.	CTS U70 bushing length 1/4", slotted shaft length 3/8"	"
R635	180 ohm 5% 1/2 Watt		S502
R636	1 Meg 5% 1/2 Watt		A-106791
*R637	250K Pot.	CTS U70 bushing length 1/4", slotted shaft length 3/8"	"
R638	1.8 Meg 5% 1/2 Watt		A-106791
R639	33K 5% 1/2 Watt		"

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
R640	1K 5% 2 Watt		A-106863
R641	570K 1% 1/2 Watt		A-106791
R642	330K 5% 1/2 Watt		"
R643	100K 5% 1/2 Watt		"
R644	100K 5% 1/2 Watt		"
R645	2.7 Meg. 5% 1/2 Watt		"
R646	15K 5% 1/2 Watt		"
*R647	10K Pot.	CTS U70 bushing length 1/4", slotted shaft length 3/8"	"
R648	33K 5% 1/2 Watt		A-106791
R649	27K 1% 1/2 Watt		A-106863
R650	13K 1% 1/2 Watt		"
R651	15K 5% 1/2 Watt		"
R652	750K 1% 1/2 Watt		A-106791

Capacitors

*C601	200 mfd 150V	Gen. Inst. Co. Type ATM 1 1/2" diam.	A-106863
*C602	200 mfd 150V	Gen. Inst. Co. Type ATM 1 1/2" diam.	"
*C603	125 mfd 350V	Gen. Inst. Co. Type ATM 1 1/2" diam.	"
C604	125 mfd 350V	Electrolytic	"
*C605	125 mfd 350V	Gen. Inst. Co. Type ATM 1 1/2" diam.	"
*C606	125 mfd 350V	Gen. Inst. Co. Type ATM 1 1/2" diam.	"
*C607	500mfd 75V	Gen. Inst. Co. Type ATM 1 1/2" diam.	"
C608	.01 mfd 400V	Paper, Tubular	A-106791
C609	.01 mfd 400V	Paper, Tubular	"
C610	.01 mfd 400V	Paper, Tubular	"
*C611	A, B, C, 3x40 mfd 400V	Gen. Inst. Co. Type ATM 1 1/2" diam.	"
C612	250 mfd 12V	Sprague # 30D157A1	A-106863
C613	.01 mfd 400V	Paper, Tubular	A-106791
C614	.01 mfd 400V	Paper, Tubular	"
C615	250 mfd 6V	Sprague # 30D138A1	S502B
*C616	A, B 50/80 mfd 475V	Gen. Inst. Co. Type ATM 1 1/2" diam.	A-106863
C617	.01 mfd 400V	Paper, Tubular	A-106791
*C618	40 mfd 400V	Gen. Inst. Co. Type ATM 1 1/8" diam.	"
*C619	40 mfd 250V	Gen. Inst. Co. Type ATM 1 1/8" diam.	"
*C620	10 mfd 50V	Gen. Inst. Co. Type TD-10-50	"
C621	.01 mfd 200V	Difilm	"
C622	.01 mfd 600V		"
C623	.01 mfd 600V		"
C624	.01 mfd 600V		"
C625	.01 mfd 600V		"

<u>Compo-</u> <u>nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
<u>Diodes</u>			
D601	Silicon Diode	Diodes, Inc. DI 56	A-106863
D602	Silicon Diode	Diodes, Inc. DI 56	"
D603	Silicon Diode	Diodes, Inc. DI 56	"
D604	Silicon Diode	Diodes, Inc. DI 56	"
D605	Silicon Diode	Diodes, Inc. DI 56	"
D606	Silicon Diode	Diodes, Inc. DI 56	"
D607	Silicon Diode	Diodes, Inc. DI 56	"
D608	Silicon Diode	Diodes, Inc. DI 56	"
D609	Silicon Diode	Diodes, Inc. DI 56	"
D610	Silicon Diode	Diodes, Inc. DI 56	"
D611	Silicon Diode	Diodes, Inc. DI 56	"
D612	Silicon Diode	Diodes, Inc. DI 56	"
D613	Silicon Diode	Diodes, Inc. DI 56	"
D614	Silicon Diode	Diodes, Inc. DI 56	"
D615	Silicon Diode	Diodes, Inc. DI 56	"
D616	Silicon Diode	Diodes, Inc. DI 56	"
D617	Silicon Diode	Diodes, Inc. DI 56	"
D618	Silicon Diode	Diodes, Inc. DI 56	"
D619	Silicon Diode	Diodes, Inc. DI 56	"
D620	Silicon Diode	Diodes, Inc. DI 56	"
D621	Silicon Diode	Diodes, Inc. DI 56	"
D622	Silicon Diode	Diodes, Inc. DI 56	"
D623	Silicon Diode	Diodes, Inc. DI 56	"
D624	Silicon Diode	Diodes, Inc. DI 56	"
D625	Silicon Diode	Diodes, Inc. DI 56	A-106606-1C
<u>Transistors</u>			
Q601	Transistor	Motorola 2N1360	Right Rear
Q602	Transistor	Motorola 2N1193	Right Rear
<u>Relays</u>			
K601	30 sec time delay		A-106863
K602	Fast Release	HAC A-600056-15	"
<u>Tubes</u>			
V601	6AU6		A-106791
V602	6AU6		"
V603	6AU6		"
V604	6AU6		"
V605	6AU6		"
V606	6BX7		"

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Number</u>	<u>Location</u>
V607	6080		A-106791
V608	6080		"
V609	6080		"
V610	6080		"
V611	5651		"
V612	12AX7		"
V613	7734		"

Transformer

T601	Power Transformer	HAC A-106625	Rear Center
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Lamps

I601	.15 Amp. No. 47 Pilot Lamps		Front Panel
I602	.15 Amp. No. 47 Pilot Lamps		"
I603	.15 Amp. No. 47 Pilot Lamps		"

Fuses

F601	Slo-Blo 5 Amp.	Littlefuse 3AG	Rear Panel
F602	Fast Acting 3/4 Amp.	Littlefuse 8AG	A-106863

7-8. High Voltage Power Supply. Dwg. A-106907

Resistors

R701	62K 5% 2 Watt		A-106796
R702	62K 5% 2 Watt		"
R703	22K 1/2 Watt 5%		"
R704	470K 1/2 Watt 5%		"
R705	100K 5% 1/2 Watt		"
R706	2.2 Meg 5% 1/2 Watt		"
*R707	2.5 Meg Pot .2 Watt	CTS Type U70 bushing length 1/4" slotted shaft length 3/8"	"
R708	2.2 Meg 5% 1/2 Watt		"
R709	10K 5% 1/2 Watt		"
R710	4.7 Meg 5% 2 Watt		"
R711	4.7 Meg 5% 2 Watt		"
*R712	2.5 Meg Pot/Switch	Mallory & Co. #LC 500MPOAC	Front Panel
R713	8.2 Meg 5% 2 Watt		A-106796
R714	8.2 Meg 5% 2 Watt		"
*R715	1 Meg Pot .2 Watt	CTS Type U70 bushing length 1/4", slotted shaft length 3/8"	"
R716	100K 5% 1/2 Watt		High Voltage Terminal Board

<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
R717	1.0 Meg 5% 1/2 Watt		A-106796
*R718	2.5 Meg Pot 2 Watt	Allen Bradley Type J, bushing length 3/8", shaft length 1/2"	Front Panel
R719	2.4 Meg 5% 2 Watt		A-106796
R720	2.4 Meg 5% 2 Watt		"

Capacitors

C701	.01 mfd 20% 600V		"
C702	.01 mfd 20% 400V		"
C703	1500 mmfd 5% 500V		"
C704	.01 mfd 20% 400V		"
C705	.01 mfd 20% 600V		"
C706	.001 mfd 20% 400V		"
C707	.005 mfd 20% 3KV		"
C708	.005 mfd 20% 3KV		"
C709	not used		"
C710	.01 mfd 20% 2.5KV		"
C711	2200 mmfd 20% 6KV		"
C712	.005 mfd 20% 3 KV		"
C713	.005 mfd 20% 3KV		"
C714	not used		
C715	.01 mfd 2.5KV		High Voltage Terminal Board
C716	.005 mfd 20% 3KV		A-106796

Tubes

V701	6AQ5		"
V702	12AU7		"

Diodes

*D701	Silicon Diode	Diodes Inc. DI 540	"
*D702	Selenium Diode	Syntron Rect. Div. D4H14OPPE	"
*D703	Silicon Diode	Diodes Inc. DI 540	"
*D704	Selenium Diode	Syntron Rect. Div. D4H14OPPE	"
*D705	Silicon Diode	Diodes Inc. DI 56	"

Lamps

VR701	Neon	Ne2A	
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Transformer

*T701	H.V. Transformer	HAC A-106626	"
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<u>Compo- nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
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7-9. Calibrator. Dwg. A-106908

Resistors

R801	10K 1/2 Watt 5%		A-106867
R802	24K 5% 1 Watt		"
R803	5.6 Meg. 5% 1/2 Watt		"
R804	5.6 Meg. 5% 1/2 Watt		"
R805	10K 5% 1/2 Watt		"
R806	24K 5% 1 Watt		"
R807	1 Meg. 5% 1/2 Watt		"
R808	2.2 Meg. 5% 1/2 Watt		"
*R809	5K Pot.	CTS Type U45 bushing length 1/4" shaft length 3/8"	"
R810	not used		
R811	10K 1% 1 Watt		S802-B
R812	10 ohm 1% 1/2 Watt		"
R813	5K 1% 1/2 Watt		S802-A-B
R814	3K 1% 1/2 Watt		S802-A-B
R815	1K 1% 1/2 Watt		S802-A-B
R816	500 ohm 1% 1/2 Watt		"
R817	300 ohm 1% 1/2 Watt		"
R818	100 ohm 1% 1/2 Watt		"
R819	50 ohm 1% 1/2 Watt		"
R820	30 ohm 1% 1/2 Watt		"
R821	20 ohm 1% 1/2 Watt.		"

Capacitors

C801	560 mmfd 5% 500V	Silver-Mica	A-106867
C802	560 mmfd 5% 500V	Silver-Mica	"
C803	56 mmfd 5% 500V	Silver-Mica	"

Tubes

V801	6DJ8		"
V802	6DJ8		"

Diodes

D801	Silicon Diode	Diodes, Inc. DI 56	"
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7-10. Z-Axis Circuit. Dwg. A-106909

R901	18K 5% 1/2 Watt		A-106867
R902	56 ohms 5% 1/2 Watt		"
R903	10K 5% 1 Watt		"

<u>Compo-</u> <u>nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
R904	20K 5% 2 Watt		A-106867
R905	20K 5% 2 Watt		"
R906	3.6K 5% 1 Watt		"
R907	3.6K 5% 1 Watt		"
R908	8.2K 5% 1/2 Watt		"
R909	not used		
R910	100K 5% 1/2 Watt		"
R911	220K 5% 1 Watt		"
R912	not used		
R913	120K 5% 1/2 Watt		"
R914	24K 5% 2 Watt		"
R915	100 ohms 5% 1/2 Watt		"
R916	24K 5% 2 Watt		"
R917	24K 5% 2 Watt		"
R918	100 ohms 5% 1/2 Watt		"
R919	10K 5% 1/2 Watt		J-801-Frame
R920	1 Meg. 5% 1/2 Watt		A-106867

Capacitors

C901	39 mmfd 5% 500V	Silver-Mica	A-106867
C902	not used		
C903	12 mmfd 5% 500V	Silver-Mica	"
C904	12 mmfd 5% 500V	Silver-Mica	"
C905	.01 mfd 10% 400V	Mylar	"
C906	.022 mfd 10% 400V	Mylar	"
C907	10 mmfd 5% 500V	Silver-Mica	J-902
C908	220 mmfd 5% 500V	Silver-Mica	A-106867

Tubes

V901	6DJ8		"
V902	6DJ8		"

Diodes

D901	Silicon Diode	Diodes, Inc. DI 56	A-106867
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Coils

L901	1 millihenry		A-106867
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7-11. Dual Trace Blanking Circuit. Dwg. A-106913

Resistors

R1301	22K 5% 1/2 Watt		A-106865
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<u>Compo-</u> <u>nents No.</u>	<u>Value</u>	<u>Mfg. Numbers</u>	<u>Location</u>
R1302	100K 5% 1/2 Watt		A-106865
R1303	22K 5% 1/2 Watt		"
R1304	5.6K 5% 1/2 Watt		"
R1305	12K 5% 1 Watt		"
R1306	220 ohms 5% 1/2 Watt		"
R1307	47K 5% 1/2 Watt		"
R1308	910K 5% 1/2 Watt		"
R1309	47K 5% 2 Watt		"

Capacitors

C1301	39 mmfd 5% 500V	Silver-Mica	A-106865
C1302	39 mmfd 5% 500V	Silver-Mica	"
C1303	not used		"
C1304	.001 mfd 5% 200V	Difilm	"
C1305	.0022 mfd 20% 100V	Difilm	"

Diodes

D1301	Germanium Rectifier	IN67A	A-106865
D1302	Germanium Rectifier	IN67A	"

Tubes

V1301	6AW8A		A-106865
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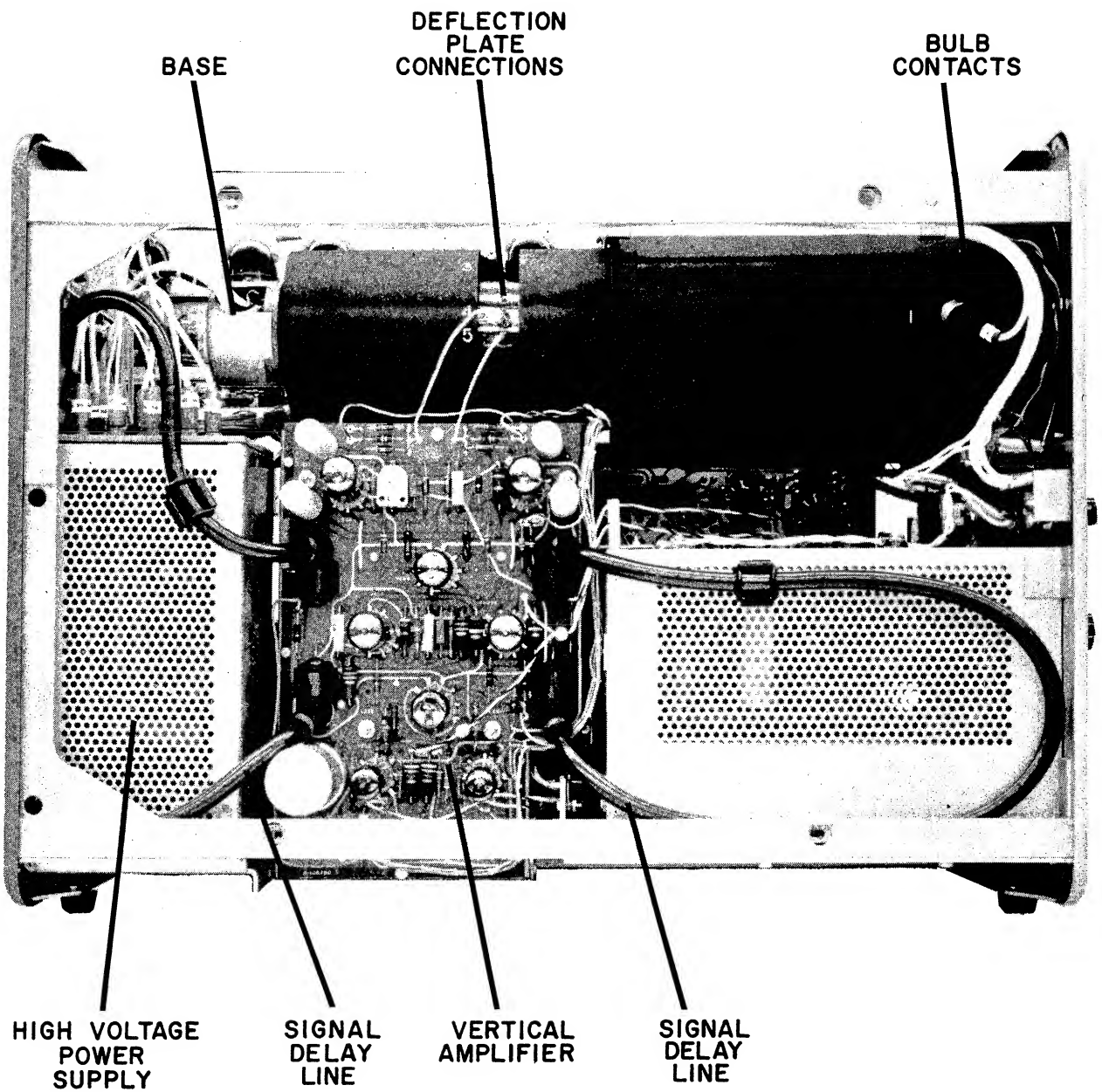


FIGURE 8 LEFT SIDE
(cover removed)

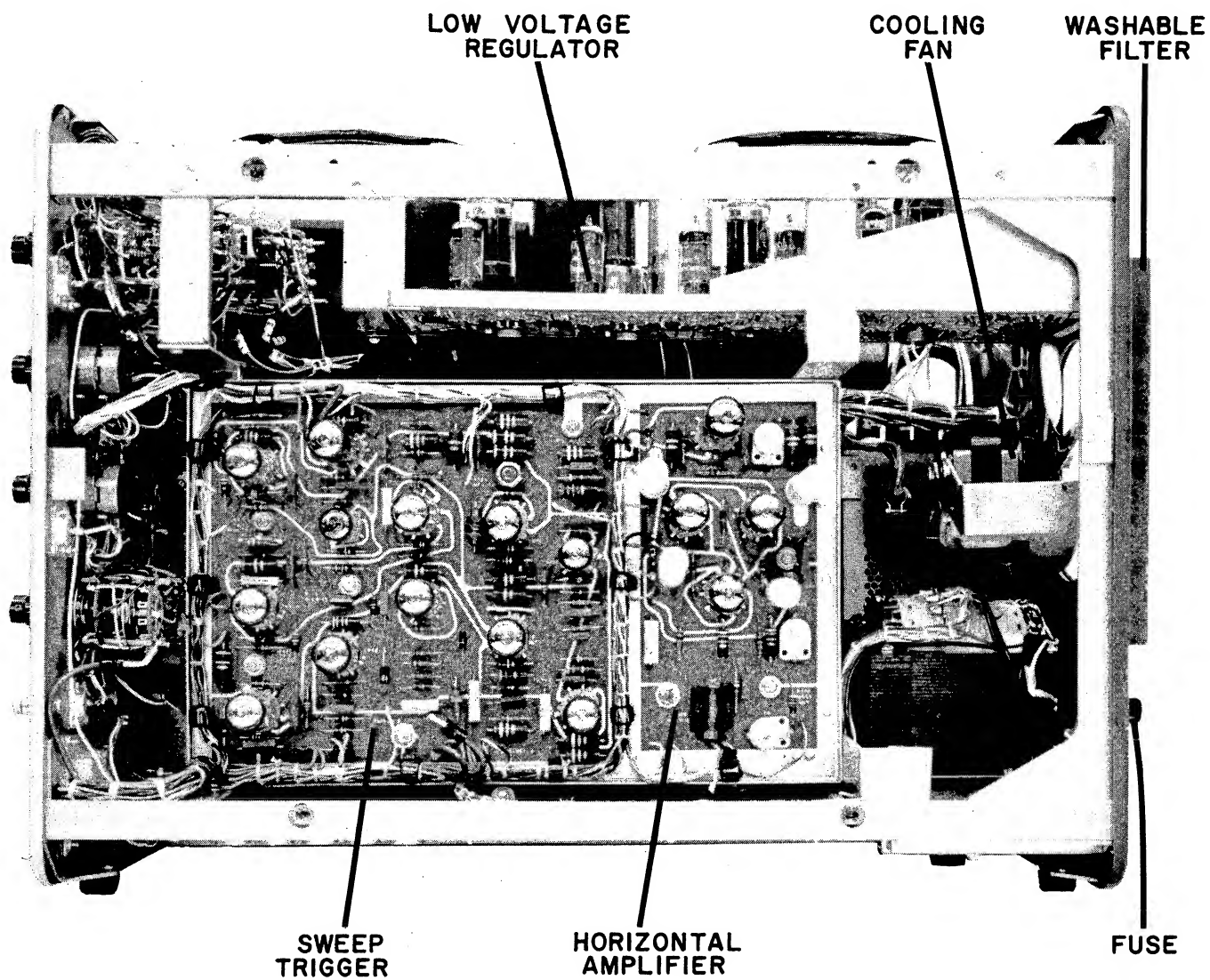


FIGURE 9 RIGHT SIDE
(cover removed)

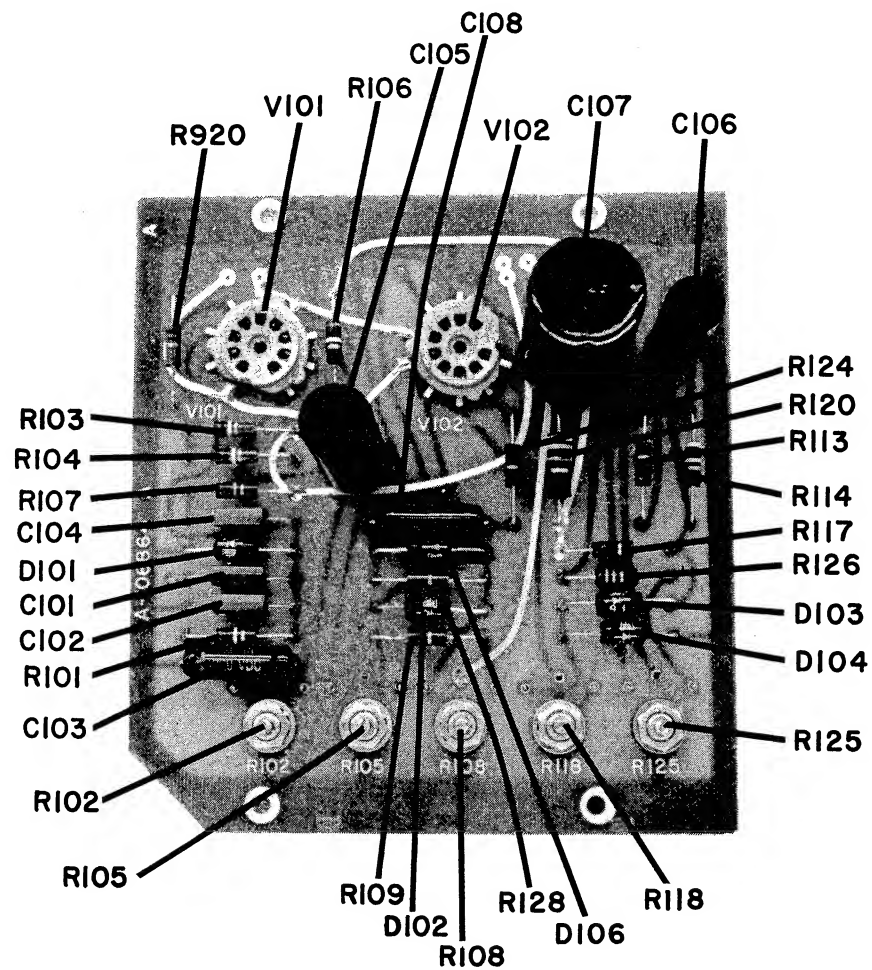


FIGURE 10 STORAGE CONTROLS ASSEMBLY A-106926
PRINTED CIRCUIT BOARD A-106864

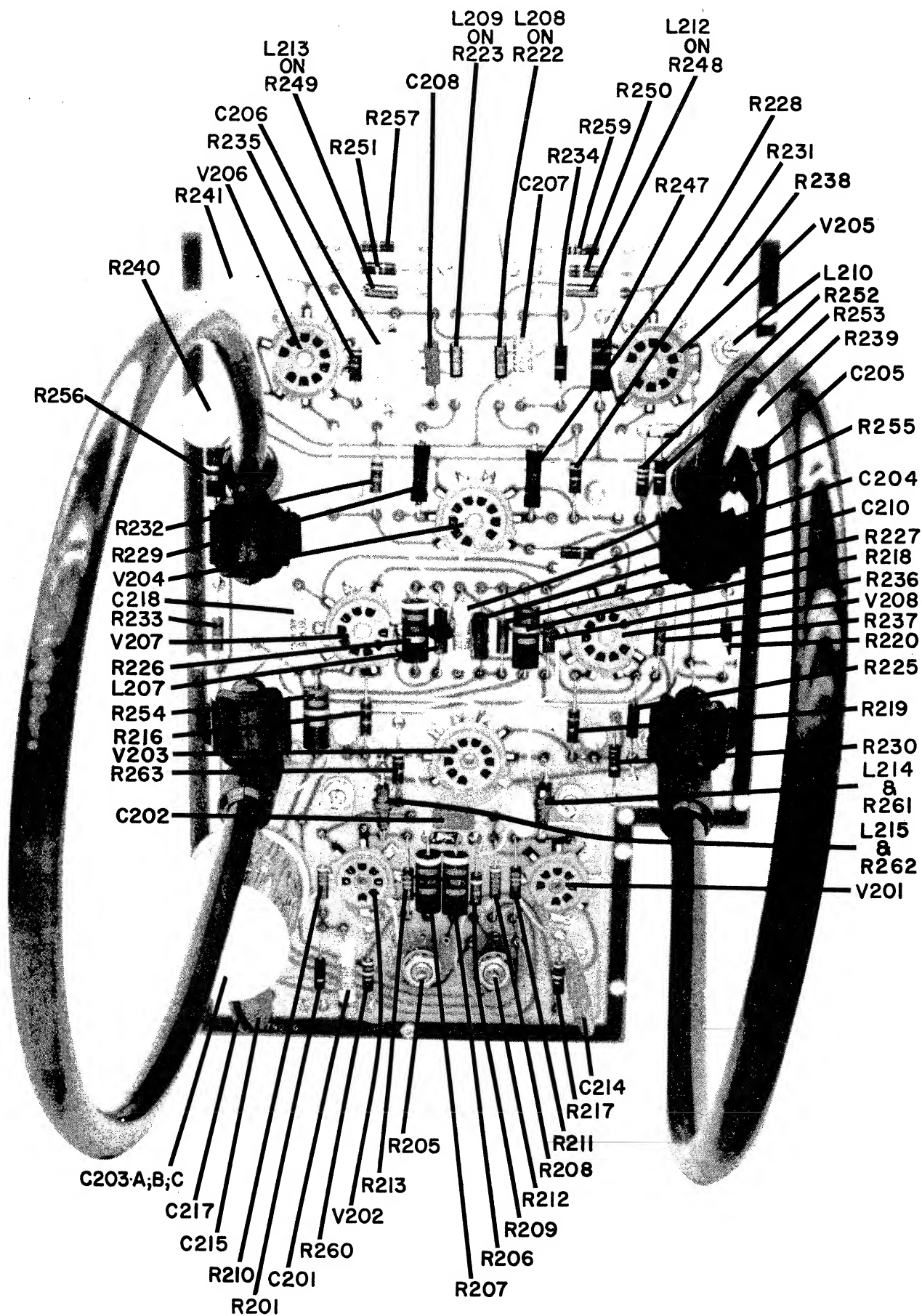


FIGURE IIa VERTICAL AMPLIFIER ASSEMBLY A-106602
(front view)
PRINTED CIRCUIT BOARD A-106790

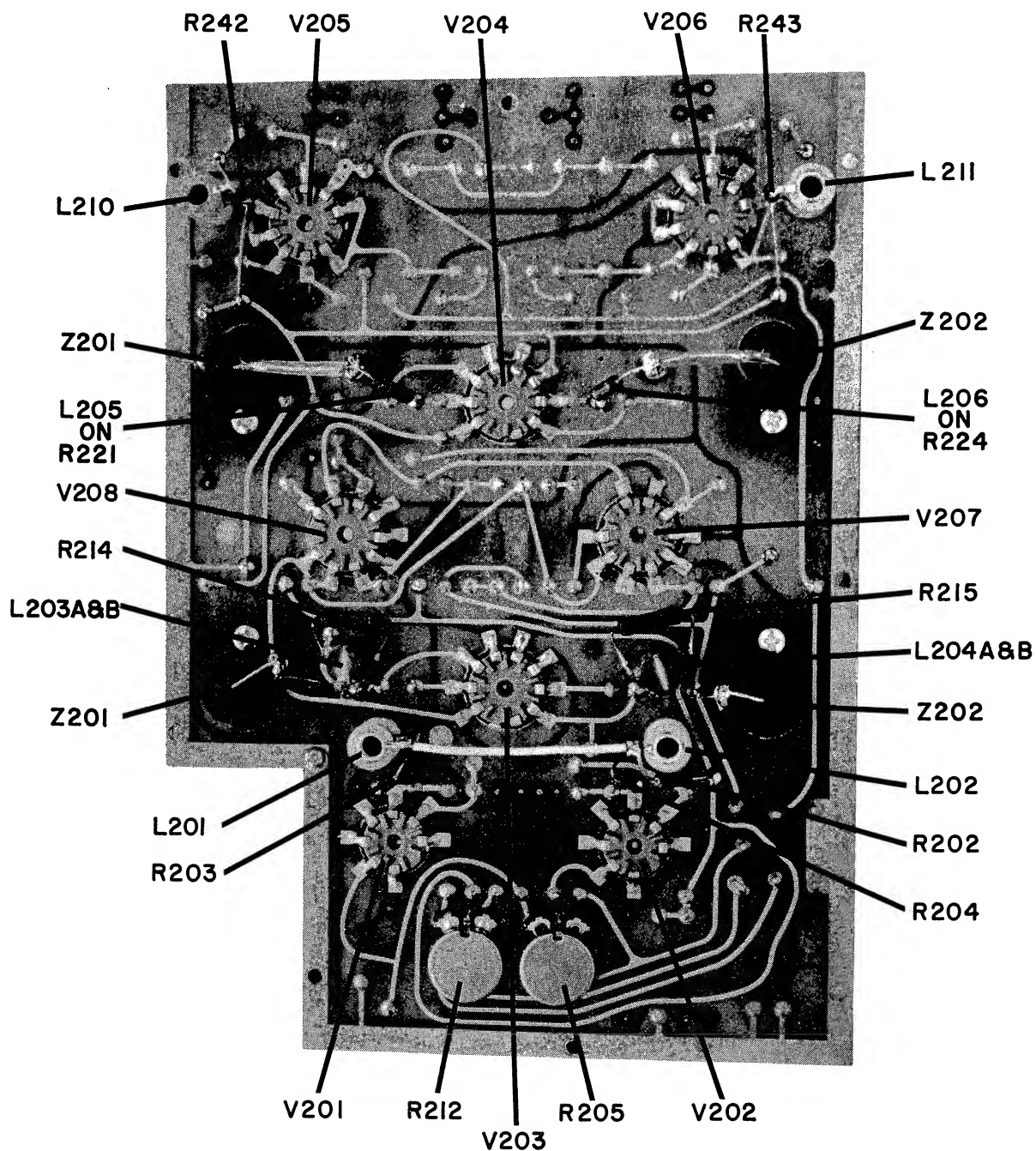


FIGURE 11b VERTICAL AMPLIFIER ASSEMBLY A-106602
 (rear view)
 PRINTED CIRCUIT BOARD A-106790

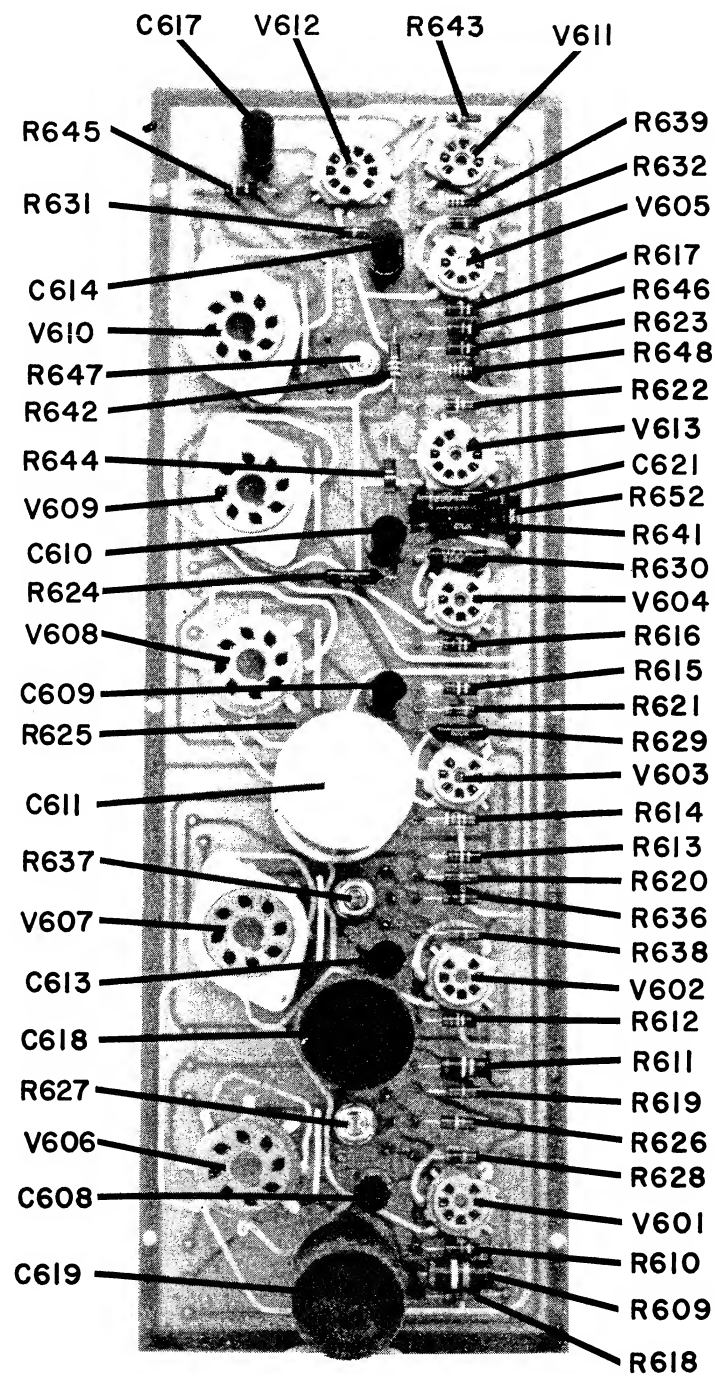


FIGURE 12 LOW VOLTAGE REGULATOR ASSEMBLY A-106606-1
 PRINTED CIRCUIT BOARD A-106791

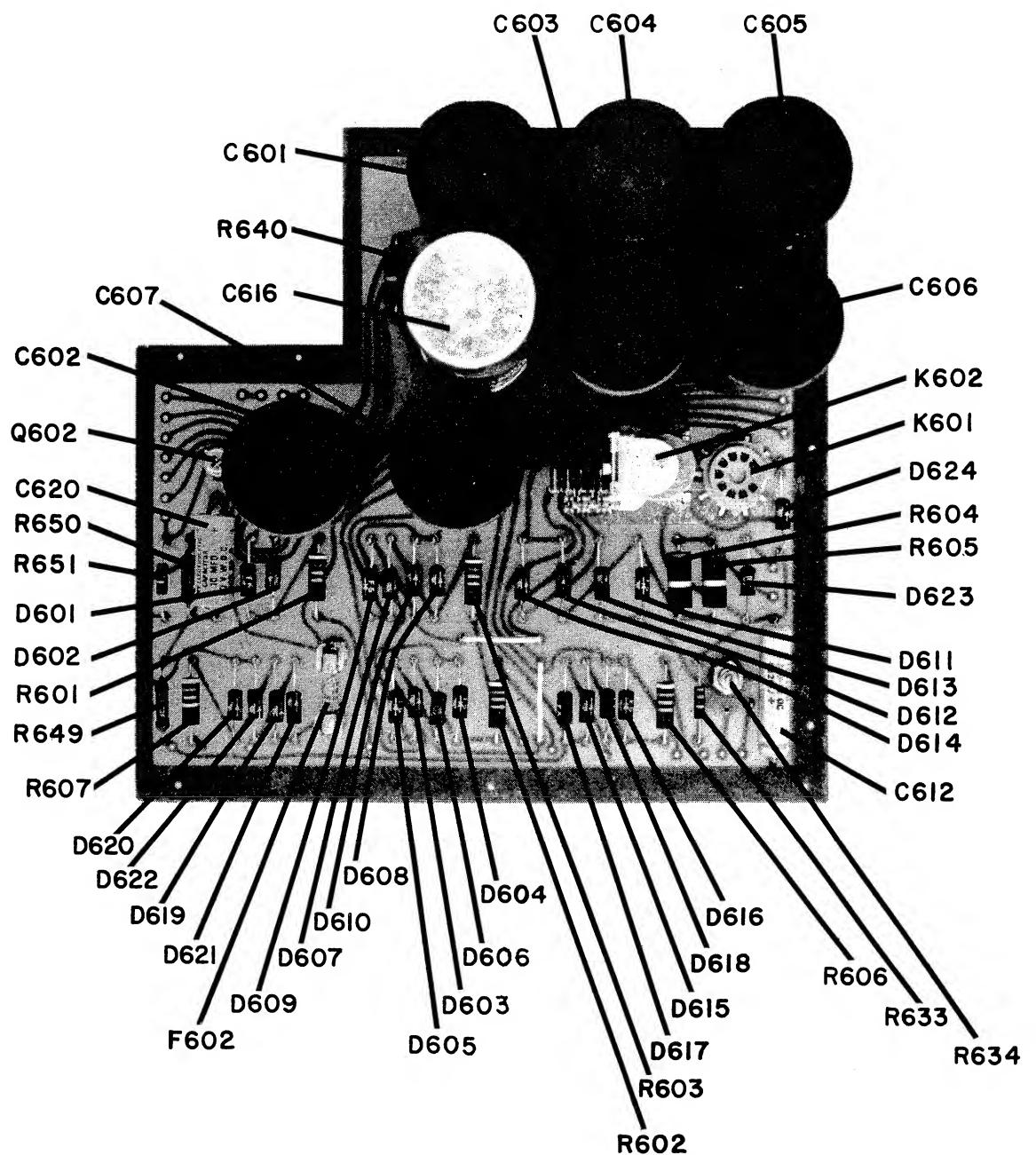


FIGURE 13 LOW VOLTAGE RECTIFIER ASSEMBLY A-106933
PRINTED CIRCUIT BOARD A-106863

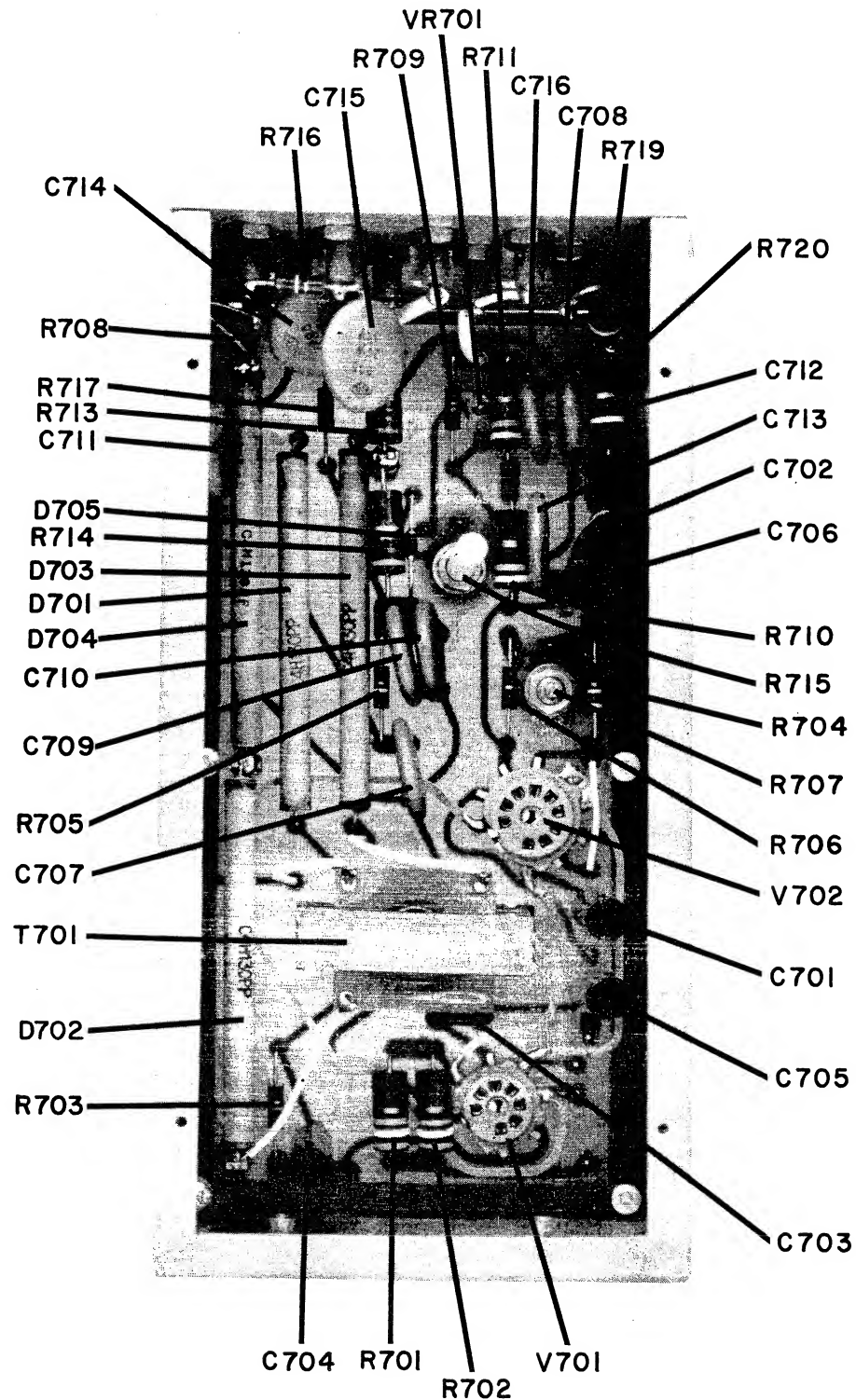


FIGURE 14 HIGH VOLTAGE POWER SUPPLY ASSEMBLY A-106615
PRINTED CIRCUIT BOARD A-106776

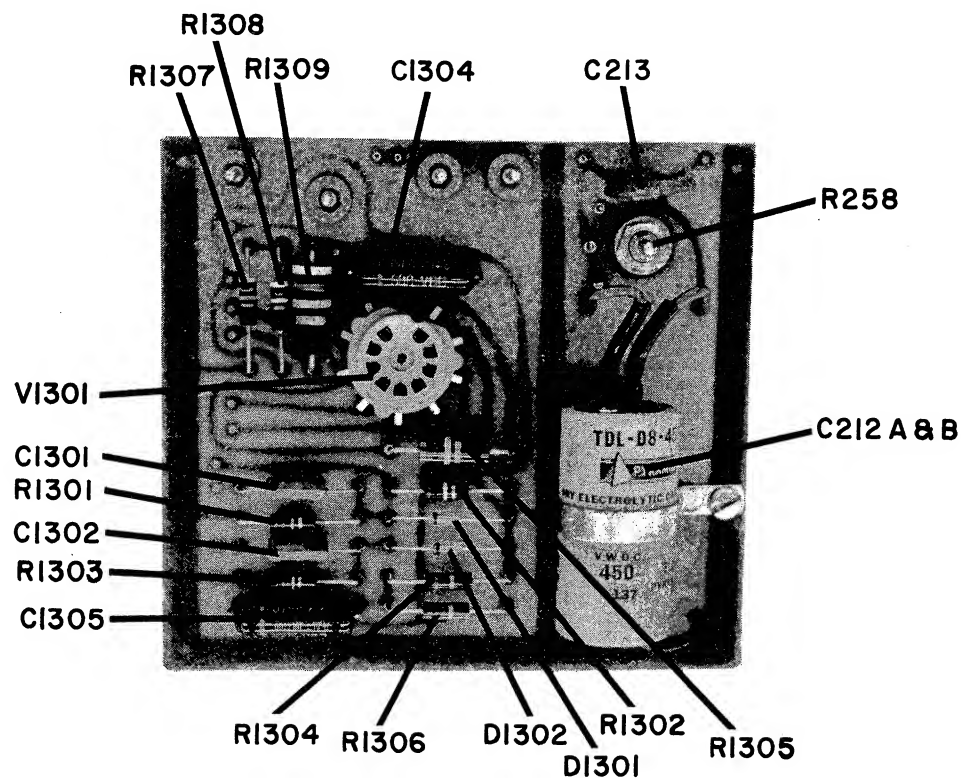


FIGURE 15 DUAL TRACE BLANKING ASSEMBLY A-106934
PRINTED CIRCUIT BOARD A-106865

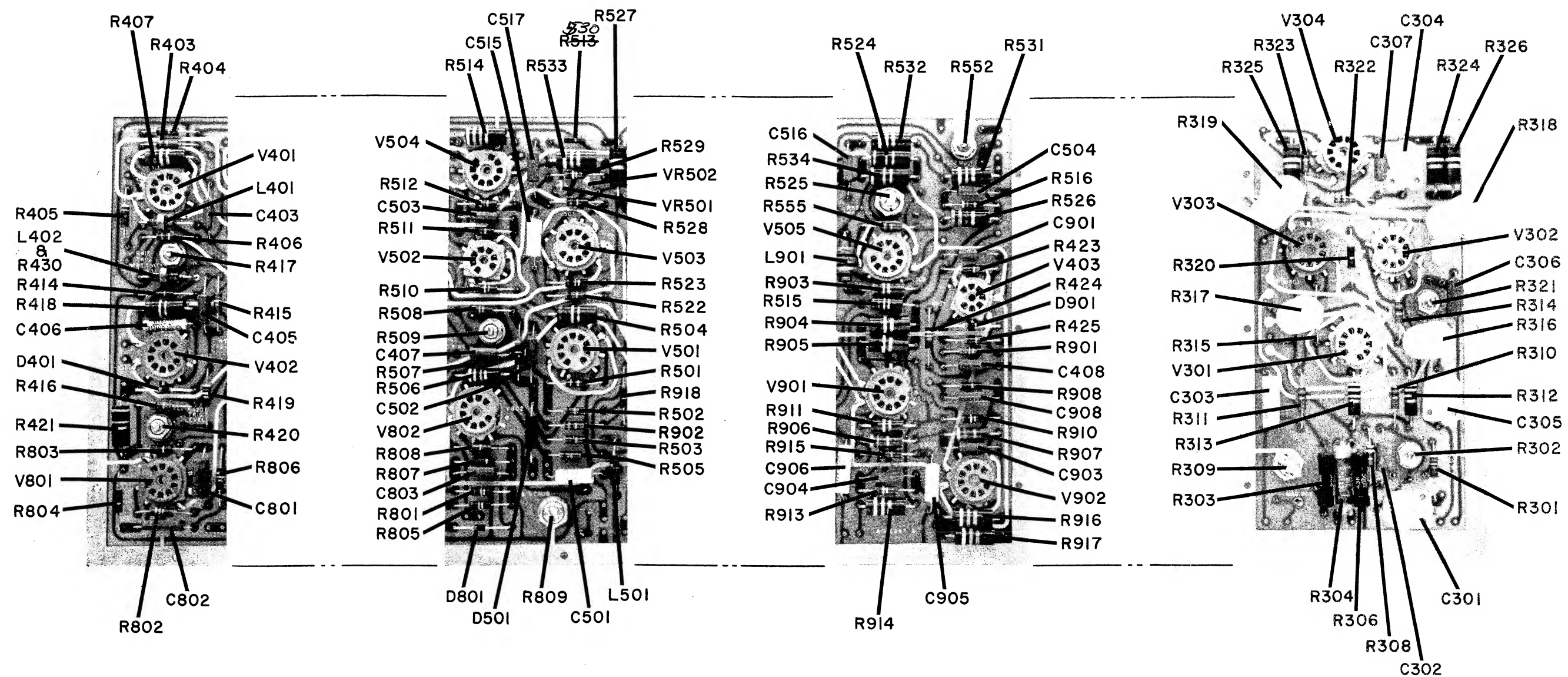
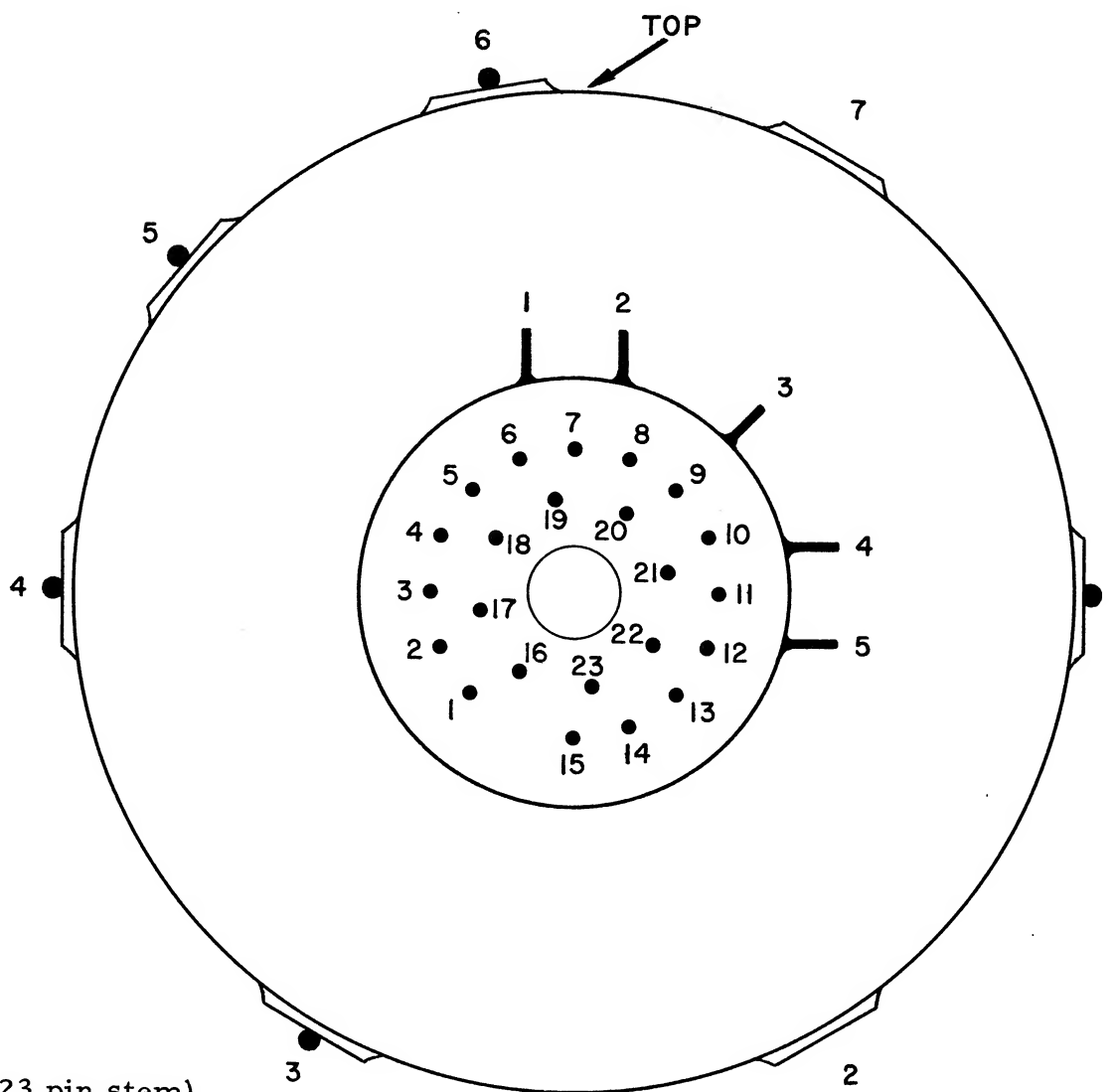


FIGURE 16 SWEEP TRIGGER - HORIZONTAL AMPLIFIER ASSEMBLY A-106603
PRINTED CIRCUIT BOARD A-106867



Base (23 pin stem)

- Pin 1. Cathode, writing gun
- Pin 2. N. C.
- Pin 3. Heater, flood gun No. 2
- Pin 4. Cathode, flood gun No. 2
- Pin 5. Grid, flood gun No. 2
- Pin 6. N. C.
- Pin 7. Grid, writing gun
- Pin 8. Anode No. 2, writing gun
- Pin 9. N. C.
- Pin 10. Focus anode
- Pin 11. Heater, flood gun No. 1
- Pin 12. Anode No. 2, flood guns
- Pin 13. Cathode, flood gun No. 1
- Pin 14. Grid, flood gun No. 1
- Pin 15. N. C.
- Pin 16. Heater, writing gun
- Pin 17. Internal connection - do not use
- Pin 18. Heater, flood gun No. 2
- Pin 19. Internal connection - do not use
- Pin 20. Internal connection - do not use
- Pin 21. Heater, flood gun No. 1

- Pin 22. Internal Connection - do not use
- Pin 23. Heater, writing gun

Deflection Plate Connections at Neck of Tube

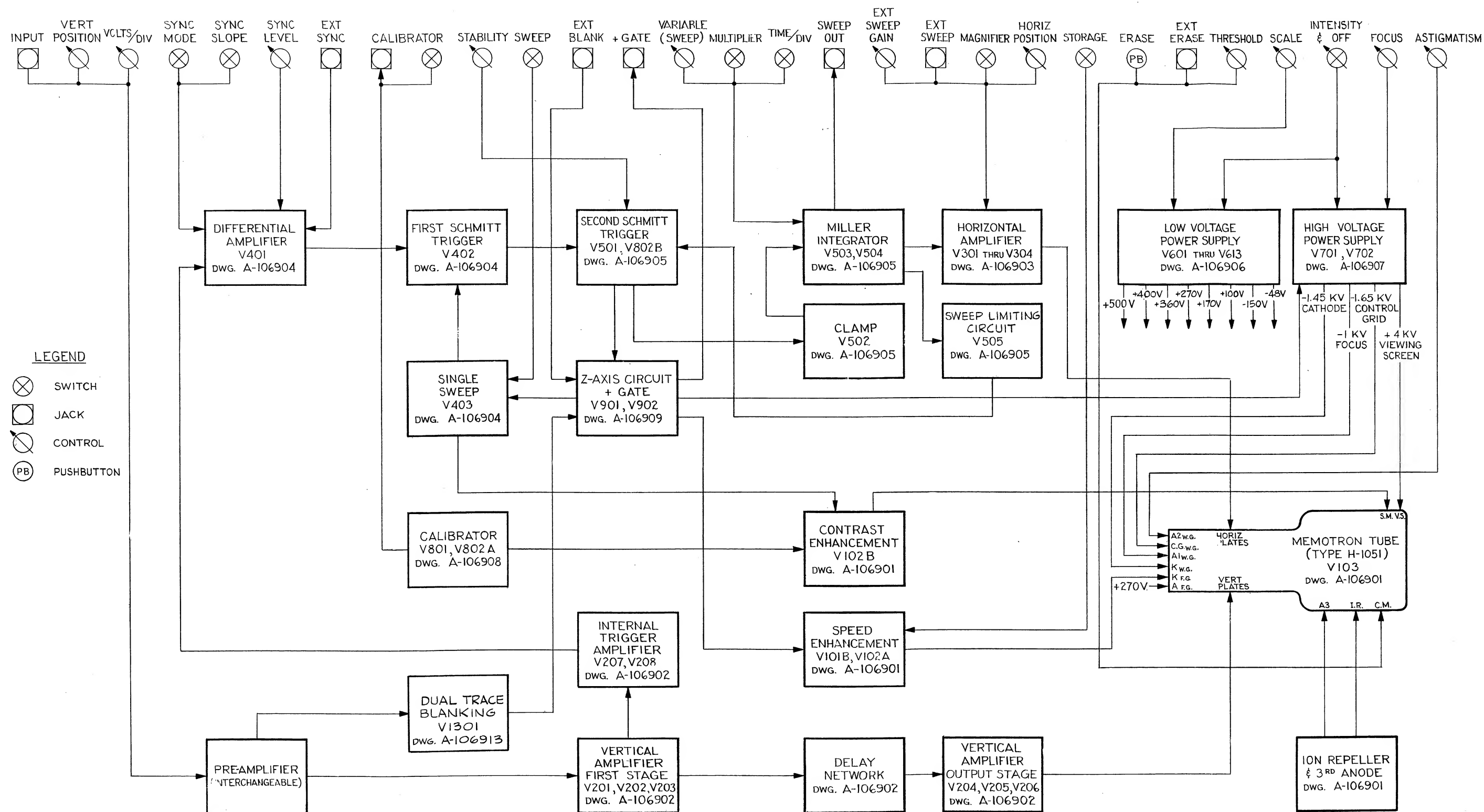
- Pin 1. Horizontal deflection plate, DH4
- Pin 2. Horizontal deflection plate, DH3
- Pin 3. Interplate shield
- Pin 4. Vertical deflection plate, DV1
- Pin 5. Vertical deflection plate, DV2

Bulb Contacts at Front End

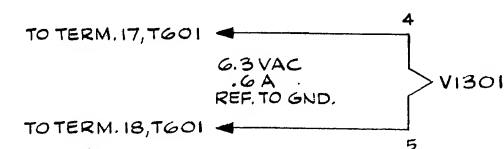
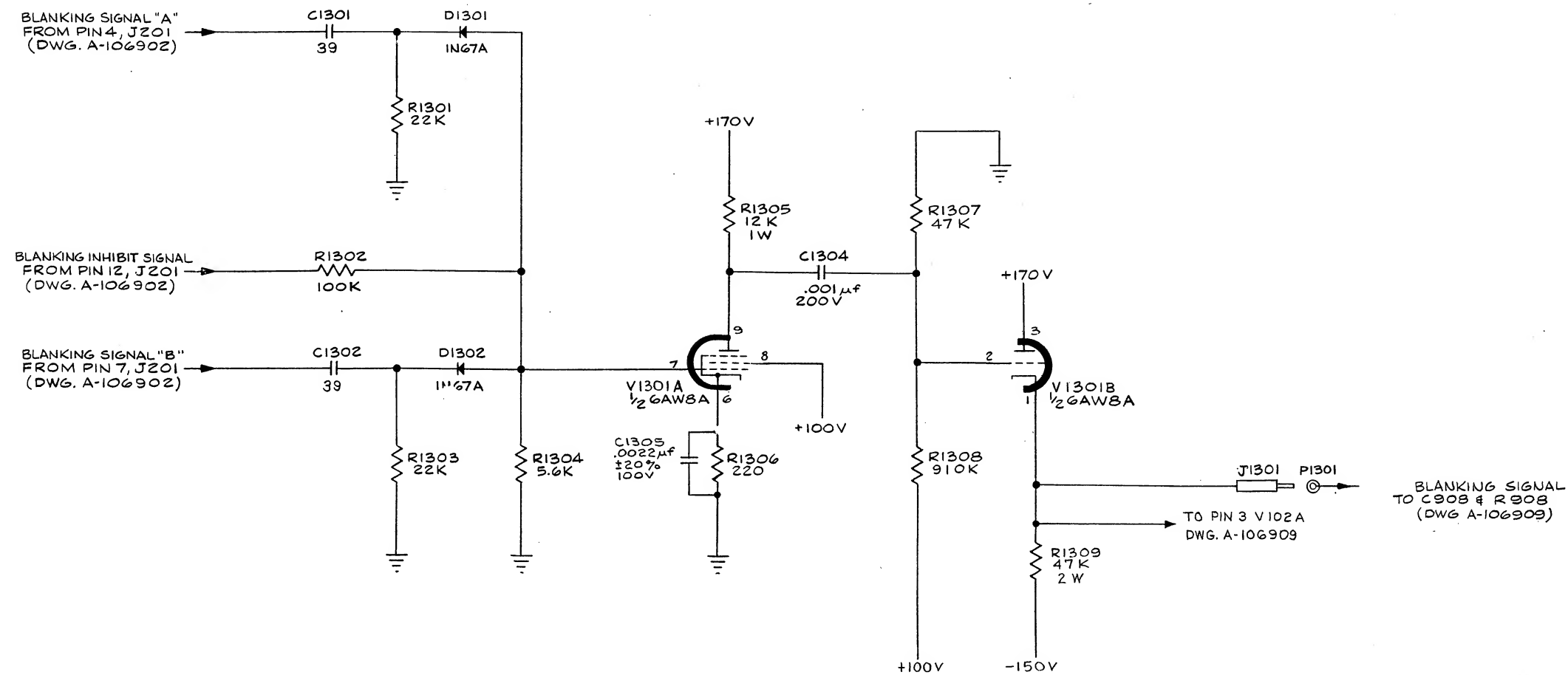
- Cap 1. Viewing screen
- Cap 2. N. C.
- Cap 3. Anode No. 3
- Cap 4. Ion Repeller mesh
- Cap 5. Collector mesh
- Cap 6. Storage mesh
- Cap 7. N. C.

FIGURE 17 REAR VIEW OF MEMOTRON TUBE

SECTION VIII
SCHEMATIC DIAGRAMS



MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
BLOCK DIAGRAM

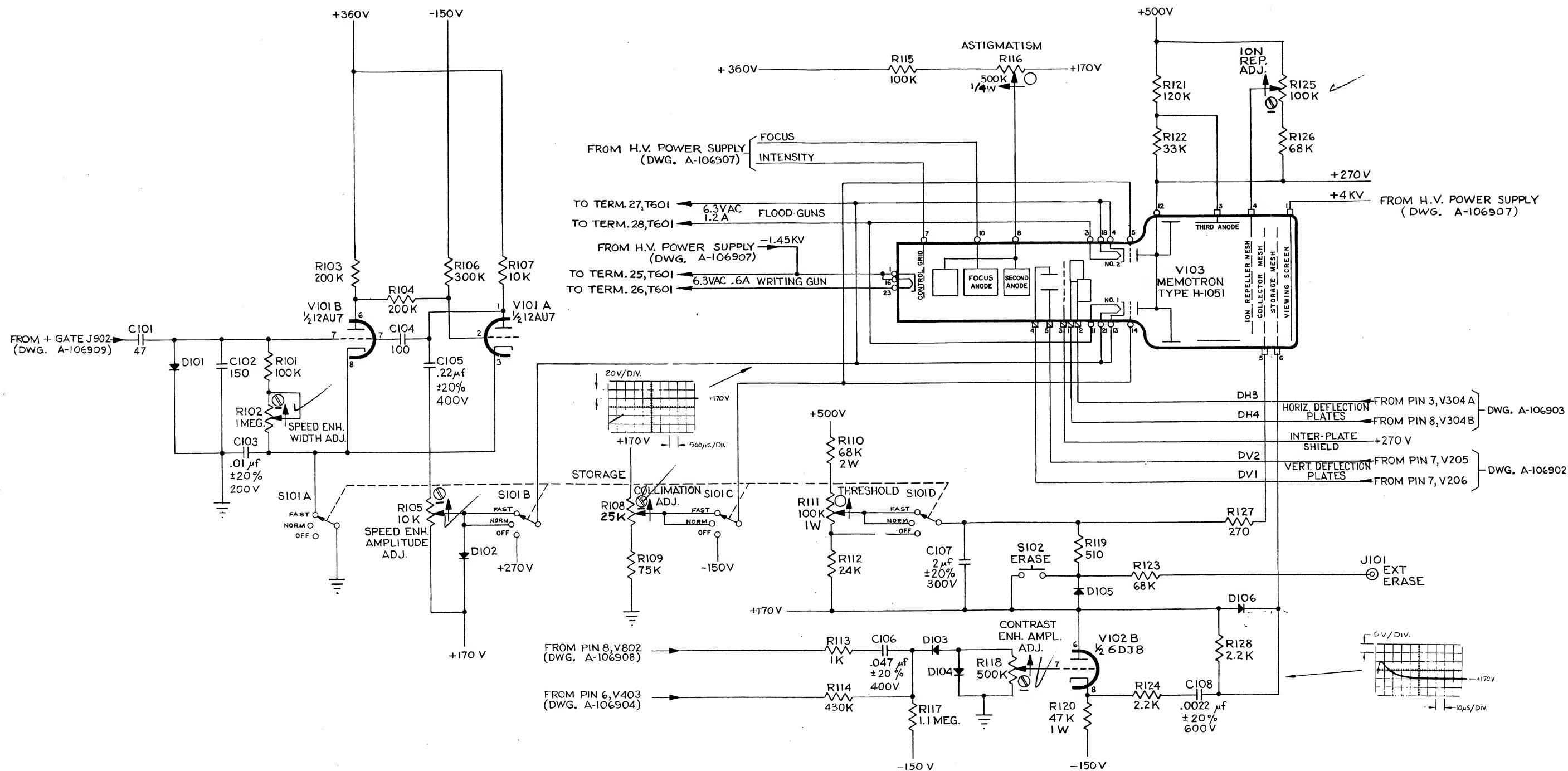


4. +100V, +170V AND -48V TO BE TAKEN FROM APPROPRIATE PINS OF J201.
3. LAST R USED IS R1309.
2. LAST C USED IS C1304.
1. RESISTORS ARE IN OHMS, $\pm 5\%$, $\frac{1}{2}$ W; CAPACITORS ARE IN μf , $\pm 5\%$, 500V, UNLESS OTHERWISE SPECIFIED.

NOTES:

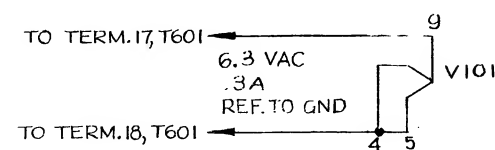
MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
DUAL TRACE BLANKING CIRCUIT
SCHEMATIC

Dwg. No. A-106913



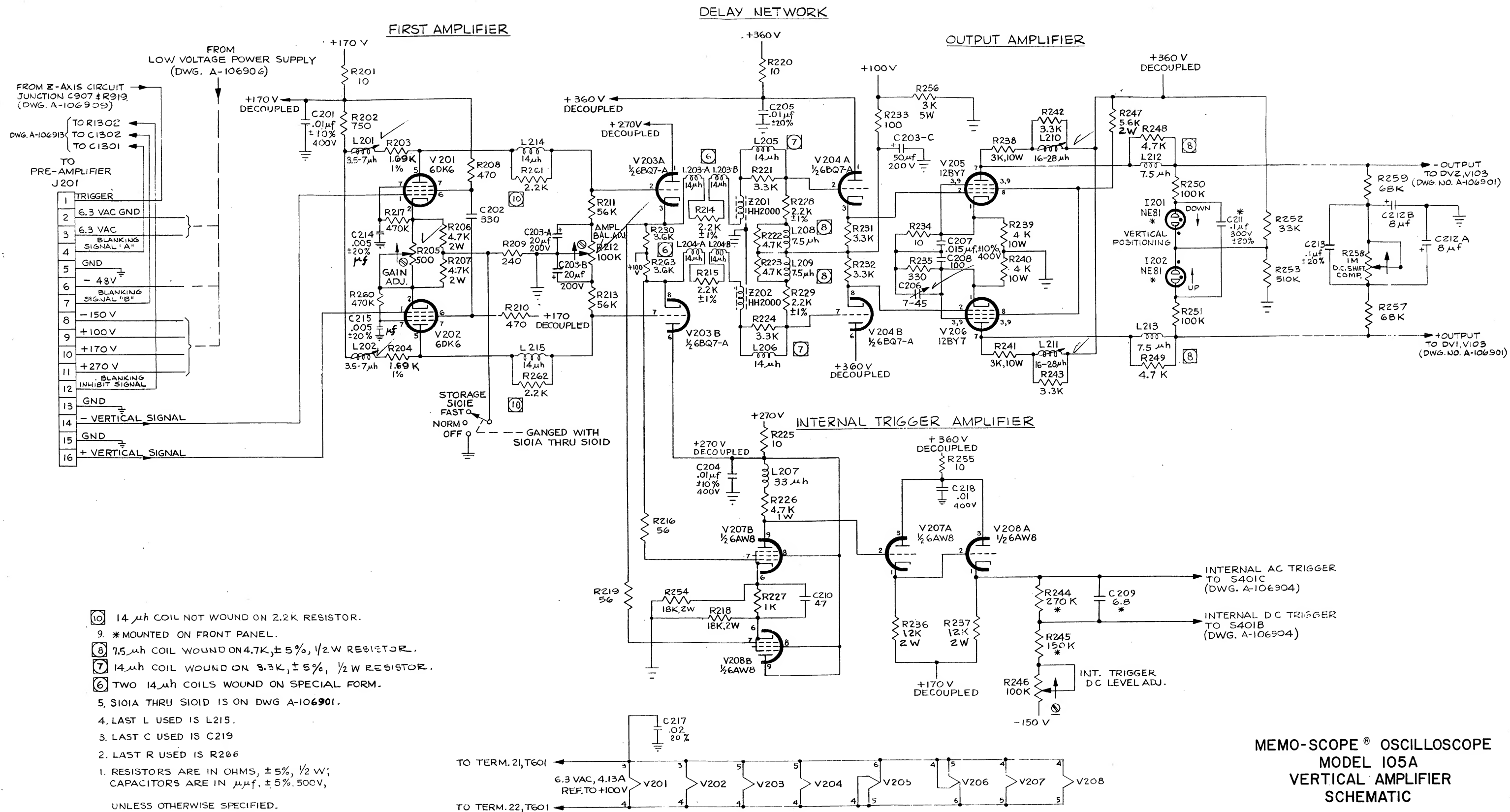
6. ALL DIODES ARE TYPE F6
5. LAST R USED IS R128.
4. LAST D USED IS D106.
3. LAST C USED IS C108.
2. MEMOTRON CONNECTIONS ARE SHOWN THUS:
 - BASE CONNECTION.
 - BULB CONNECTION.
 - NECK CONNECTION.
1. RESISTORS ARE IN OHMS, $\pm 5\%$, $\frac{1}{2}W$;
CAPACITORS ARE IN μf , $\pm 5\%$, 500V,
UNLESS OTHERWISE SPECIFIED.

NOTES:



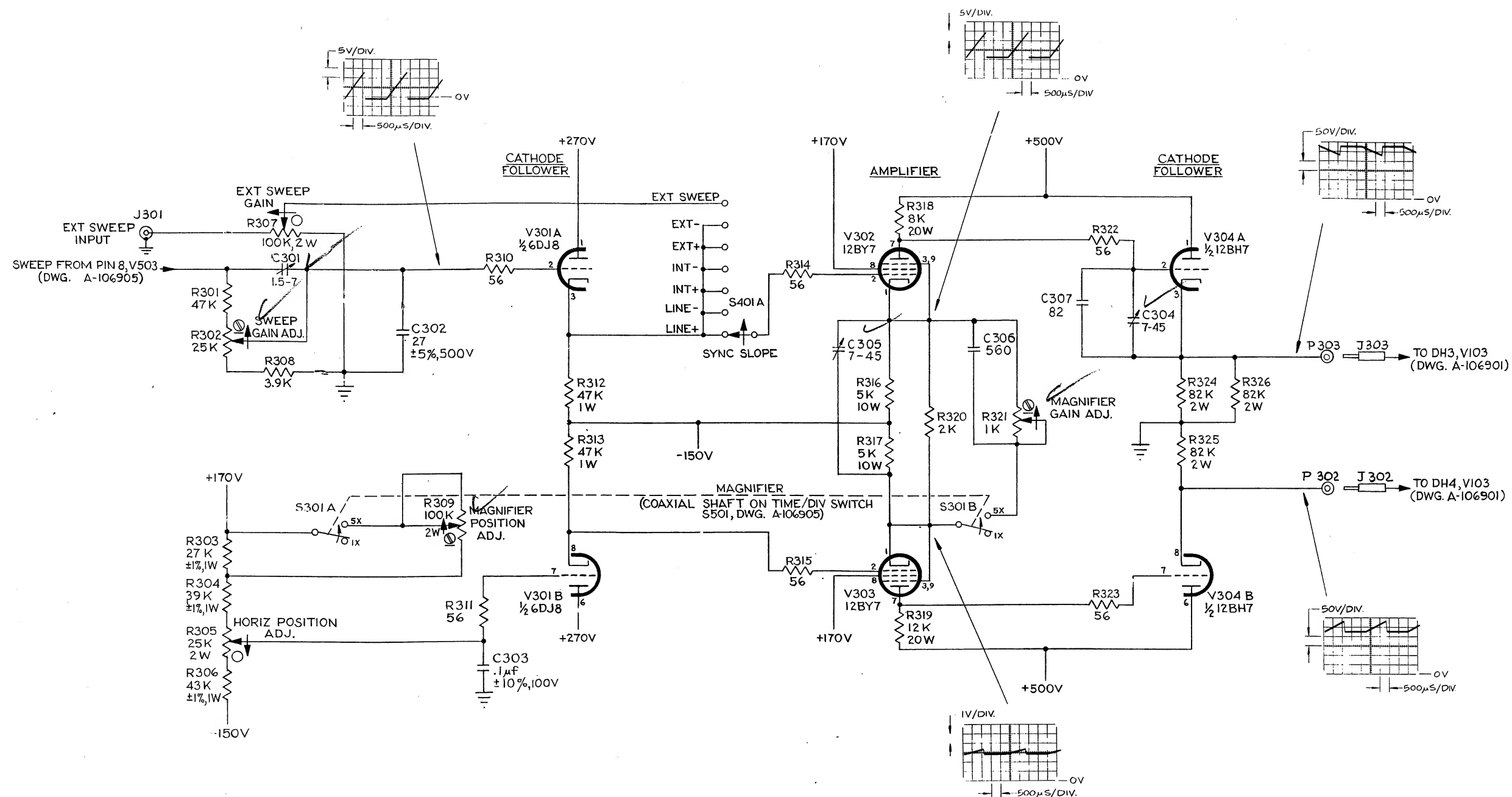
MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
MEMOTRON STORAGE CONTROLS
SCHEMATIC

Dwg. No. A-106901



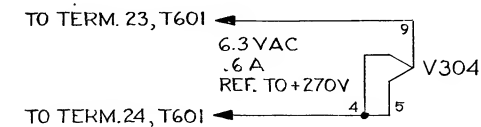
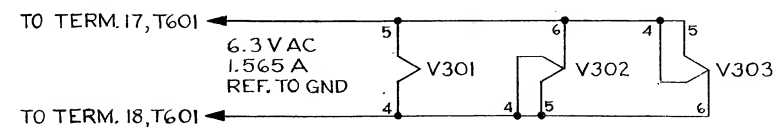
MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
VERTICAL AMPLIFIER
SCHEMATIC

Dwg. No. A-106902



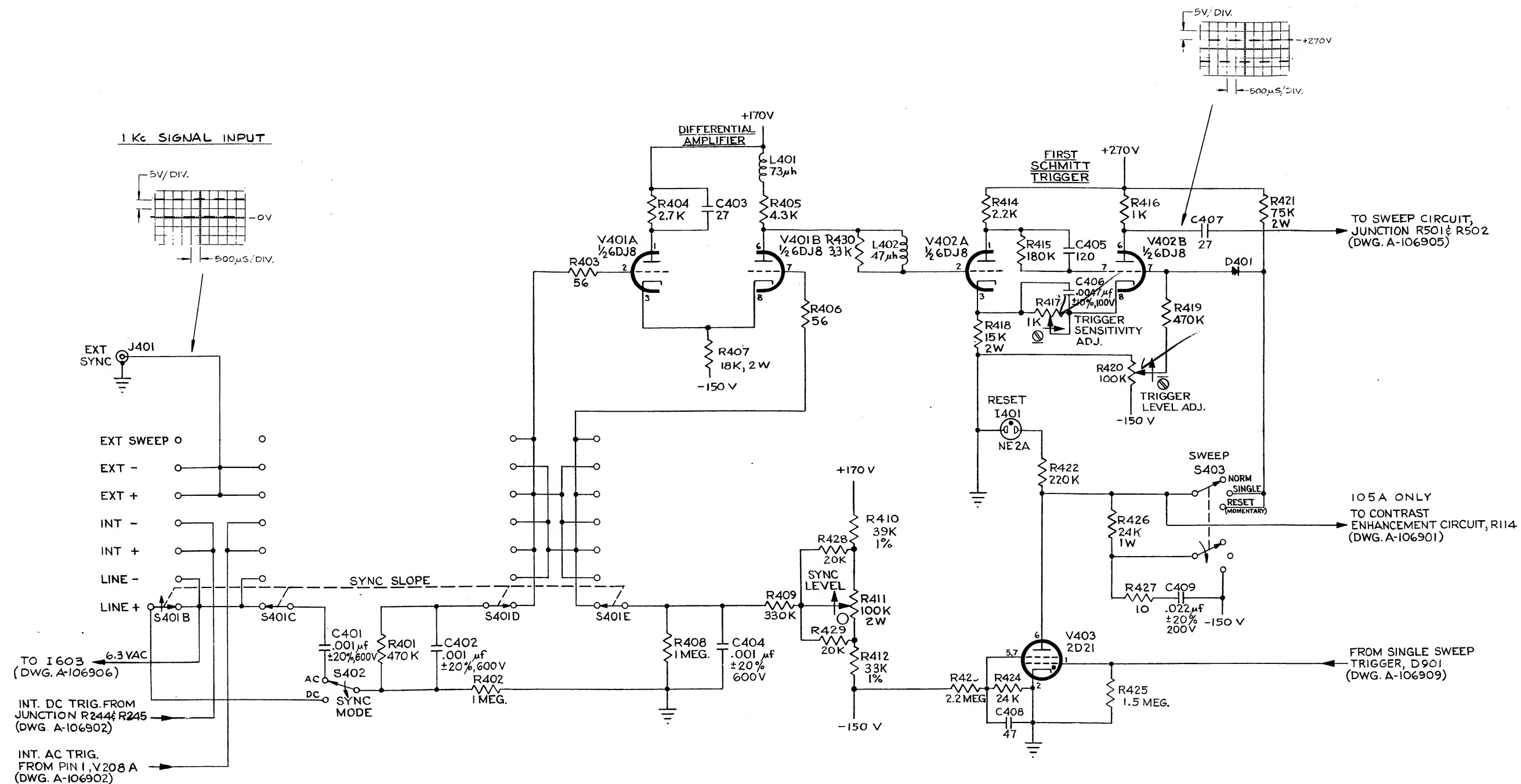
4. LAST R USED IS R326.
3. LAST C USED IS C307.
2. S401 B,C,D & E ARE ON DWG. A-106904.
1. RESISTORS ARE IN OHMS, $\pm 5\%$, $\frac{1}{2}$ W;
CAPACITORS ARE IN μf , $\pm 5\%$, 500V,
UNLESS OTHERWISE SPECIFIED.

NOTES:



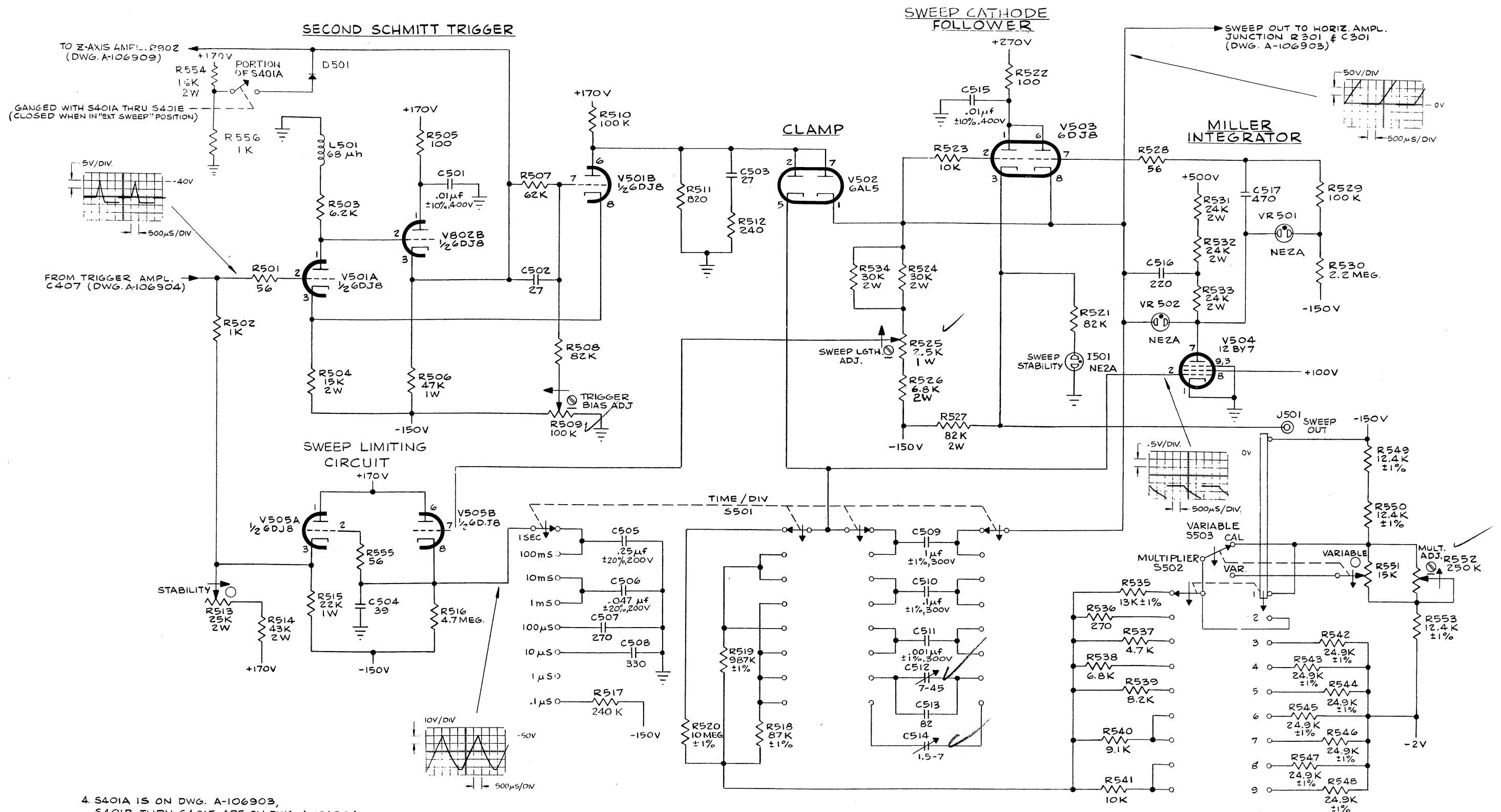
MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
HORIZONTAL AMPLIFIER
SCHEMATIC

Dwg. No. A-106903



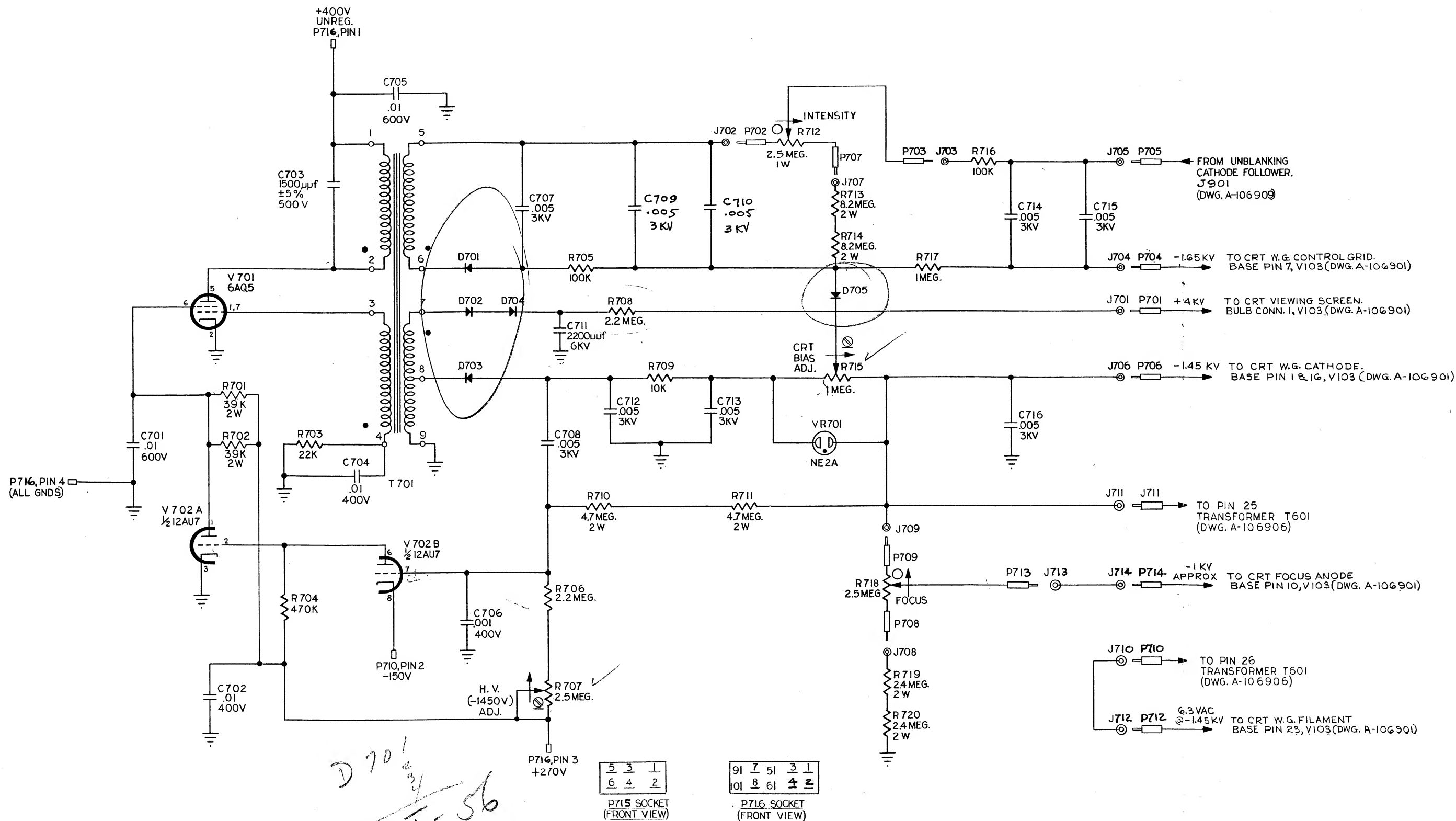
MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
TRIGGER AMPLIFIER
SCHEMATIC

Dwg. No. A-106904

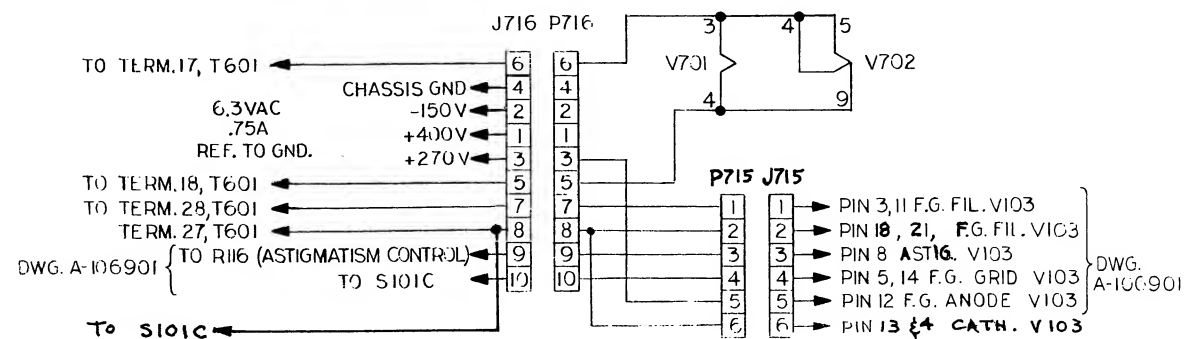


- NOTES:
1. RESISTORS ARE IN OHMS, $\pm 5\%$, $\frac{1}{2}$ W; CAPACITORS ARE IN μ mf, $\pm 5\%$, 500V, UNLESS OTHERWISE SPECIFIED.
 2. LAST R USED IS R556.
 3. LAST C USED IS C517.
 4. S401A IS ON DWG. A-106903, S401B THRU S401E ARE ON DWG. A-106904.

MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
SWEEP GENERATOR
SCHEMATIC



- NOTES:
- ALL GROUNDS MARKED \perp TO BE CONNECTED TO PIN 4, P710
 - LAST R USED IS R720
 - LAST C USED IS C716
 - RESISTORS ARE IN OHMS, $\pm 5\%$, $\frac{1}{2}$ W; CAPACITORS ARE IN μf , $\pm 20\%$, UNLESS OTHERWISE SPECIFIED.



MEMO-SCOPE® OSCILLOSCOPE
MODEL 105A
HIGH VOLTAGE POWER SUPPLY
SCHEMATIC

Dwg. No. A-106907

INDUSTRIAL SYSTEMS DIVISION

HUGHES AIRCRAFT COMPANY

· WARRANTY ·

Applicable to Instruments and/or Associated Equipment

1. Instruments sold by the Industrial Systems Division (ISD) of Hughes Aircraft Company are warranted against defects in material and workmanship for a period of six months from date of shipment.* ISD's entire warranty obligation is limited to making adjustment, at its election, by repairing, replacing or refunding the purchase price of any Instrument which is returned within the warranty period and which ISD finds to be so defective.
2. Shipping and packing instructions must be obtained from ISD before Instruments are returned. Return is at Buyer's risk and expense. Where adjustment is allowed, repaired or replaced Instruments will be returned by Buyer with transportation charges within the United States prepaid. Transportation charges beyond the United States will be charged to Buyer. Where adjustment is not allowed, Instruments will be returned to Buyer at Buyer's expense and a charge of five percent of the original purchase price will be made to cover cost of inspection and handling.
3. Subject to the provisions of the "Patent Indemnity" clause of its Sales Terms and Conditions, ISD also warrants that it has the right to sell its Instruments, that Buyer shall have and enjoy quiet possession thereof as against any lawful claims existing at the time of sale by ISD, and that said Instruments are free from any charge or encumbrances in favor of third persons existing at the time of sale by ISD.
4. Adjustment will not be allowed for Instruments or components thereof which have been subjected to abuse, improper application, installation or alteration, accident or negligence in inspection, use, storage, transportation or handling, or which have not been operated in accordance with ISD's Instruction Manual. Alteration or removal of serial number or identification markings void the warranty.
5. The warranty set forth herein constitutes ISD's entire warranty, express, implied or statutory with respect to its Instruments, and states the full extent of its liability for breach of warranty and for damages, whether direct, special or consequential, resulting from any such breach. No change whatsoever thereto shall be binding upon ISD unless in writing and signed by a duly authorized representative of ISD.
6. ISD reserves the right to make changes in the design of any of its Instruments without incurring any obligation to make such changes in Instruments previously sold or on order.
7. Wherever used herein the term Instruments refers to ISD's MEMO-SCOPE^(S) Oscilloscope and associated equipment therefor.

* Tubes, other than MEMOTRON^(U) tubes, are warranted only as set forth in paragraph 3. MEMOTRON tubes are warranted only as provided in the manufacturer's storage tube warranty, appearing on the reverse side hereof.

Creating a new world with **ELECTRONICS**

IW Rev. 1-61

INDUSTRIAL SYSTEMS DIVISION

HUGHES

HUGHES AIRCRAFT COMPANY

INTERNATIONAL AIRPORT STATION
P.O. BOX 90904
LOS ANGELES 45, CALIFORNIA

VACUUM TUBE PRODUCTS DIVISION

HUGHES AIRCRAFT COMPANY

· WARRANTY ·

Applicable to Direct Viewing Bi-stable Type Storage Tubes

Such as MEMOTRON[®] and TYPOTRON[®] Tubes

1. For a period of six months after shipment, bi-stable type direct viewing storage tubes, other than Developmental Tubes, are warranted against defects in material and workmanship. This warranty is not an indication of tube life since under normal operation or usage average life expectancies exceed the warranty. Tubes are dated-coded according to the Electronics Industries Association standard three digit code system, and for purposes of determining the extent of any warranty adjustment, are placed in the following two categories:

INITIAL REJECTS: Tubes determined by Seller to have proved defective in material or workmanship during initial or acceptance tests and within thirty days after shipment by Seller.

FIELD REJECTS: Tubes determined by Seller to have proved defective in material or workmanship more than thirty days after shipment or after installation in equipment, but within the warranty period.

Any tube determined by Seller to be defective as an INITIAL REJECT will be repaired or replaced free of charge. Any tube determined by Seller to be defective as a FIELD REJECT, will, at Seller's option, either be repaired free of charge or replaced with a prorated charge. The prorated charge will be computed by deducting from the price of the replacement tube a sum equivalent to one-sixth thereof for each month elapsed between the date of shipment of the defective tube and the date Seller determines that said tube became defective.

2. Adjustments are limited to claims presented by Buyer in writing to Seller within thirty (30) days after Buyer first has reason to believe the tube to be defective.

3. Shipping and packing instructions must be obtained from Seller before tubes are returned. Buyer will pay for packing, labor, transportation, and transit insurance costs for returned tubes. Credit for returned transportation and transit insurance costs within the United States (except Alaska and Hawaii) will be issued by Seller provided adjustment is allowed.

4. Inspection for adjustment may require destruction of the tube. Replacement or other adjustment for a destroyed tube will be allowed only if such tube is found subject to adjustment by Seller's inspection.

5. Buyer will be notified by Seller of tubes not subject to adjustment. Unless disposition instructions as to such tubes are received from Buyer within thirty (30) days from the date of Seller's notification, such tubes, or fragments thereof where tubes have been destroyed in inspection, will be returned to Buyer, transportation collect. Where inspection shows tubes not to be subject to adjustment, a charge of 10% of original purchase price will be made to Buyer to cover Seller's cost of inspection and handling.

6. Adjustment will not be allowed for tubes which have been subjected to abuse, improper application or installation, alteration, accident or negligence in use, storage, transportation or handling; nor for tubes if original identification markings thereon have been removed, defaced or altered.

7. Due to their nature and varying applications, Developmental Tubes are not warranted except to the extent provided in paragraph 10 below.

8. Seller shall make final determination as to the existence and cause of a defect, whether a tube is a production type or developmental tube, and whether any adjustment will be allowed, and, if allowed, whether such adjustment will be by repair, credit, or replacement, with or without a prorated charge.

9. Replacements for tubes subject to adjustment will be shipped F.O.B. city of destination with transportation charges allowed by Seller to city of destination. However, if destination is Hawaii, Alaska or any other point beyond the continental limits of the United States, transportation beyond these limits will be charged to Buyer.

10. Subject to the provisions of the "Patent Indemnity" clause of its sales terms and conditions, Seller also warrants that it has the right to sell its tubes, that Buyer shall have and enjoy quiet possession thereof as against any lawful claims existing at the time of sale by Seller, and that said tubes are free from any charge or encumbrance in favor of third persons existing at the time of sale by Seller.

11. The foregoing constitutes Seller's entire warranty, express, implied or statutory with respect to its tubes, and states the full extent of its liability for breach of warranty and for damages, whether direct, special or consequential, resulting from any such breach. No change whatsoever thereto shall be binding upon Seller unless in writing and signed by a duly authorized representative of Seller.